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CONTENTS OF VOLUME 57

A SYNOPSIS OF THE GENUS MESOSTOMA EHRENBERG 1835. *F. F. Ferguson and Wayland J. Hayes, Jr.* 1
STUDIES ON THE TURBELLARIAN FAUNA OF THE NORFOLK AREA. VI. *E. Ruffin Jones, Jr., and F. F. Ferguson* 53
THE FOOD AND FEEDING HABITS OF THE WHALE SHARK, RHINEODON TYPUS. *E. W. Gudger* 57
ANNUAL REPRODUCTION CYCLE OF THE MALE FENCE LIZARD. *Paul D. Altland* 73
CRETINOID PROGENY FROM HYPERTHYROIDIZED RATS. *Bert Cunningham* 85
FAUNA OF PINE BARK. *Helen Ramsey* 91
LETTERS FROM THE COLLECTION OF DR. CHARLES WILKINS SHORT. *W. C. Coker* 98
PROCEEDINGS OF THE FORTIETH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE 169
PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY 216
MAN AND MINERALS. *Jasper L. Stuckey* 218
THE GENUS DREPANAPHIS DEL GUERCIO EAST OF THE ROCKY MOUNTAINS. *Clyde F. Smith* 226
A NEW TURBELLARIAN (RHABDOCOELE) FROM BEAUFORT, NORTH CAROLINA, TRIGONOSTOMUM PRYTHERCHI N. SP. *William A. Kepner, F. F. Ferguson, and Margaret A. Stirewalt* 243
A NEW TURBELLARIAN (ALLOEOCOELE) FROM BEAUFORT, NORTH CAROLINA, PLAGIOSTOMUM DAHLGRENI N. SP. *William A. Kepner, M. A. Stirewalt, and F. F. Ferguson* 253
SOME OBSERVATIONS ON FRESHWATER ALGAE OF FLORIDA. *Roy M. Whelden* 261
POLYDORA, A PEST IN SOUTH CAROLINA OYSTERS. *G. Robert Lunz* .. 273
A NEW GEOMETRICAL INTERPRETATION OF EINSTEIN'S SPECIAL RELATIVITY THEORY. *Archibald Henderson* 284
HISTORY OF GEOLOGICAL INVESTIGATIONS IN NORTH CAROLINA. *Joseph Hyde Pratt* 295
NOTES ON EPHEMEROPTERA AND AQUATIC DIPTERA OF WESTERN NORTH CAROLINA. *Thelma Howell* 306
RECORDS OF THE BROOK LAMPREY, LAMPETRA AEPYPTERA (ABBOTT), FROM THE ATLANTIC DRAINAGE OF NORTH CAROLINA AND VIRGINIA. *Edward C. Raney* 318
CELLULOSE DECOMPOSITION BY THE SAPROPHYTIC CHYTRIDS. *Alma J. Whiffen* 321
THE SOUTHEASTERN SECTION OF THE BOTANICAL SOCIETY OF AMERICA. *H. L. Blomquist* 331

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A SYNOPSIS OF THE GENUS *MESOSTOMA* EHRENBERG 1835

BY FREDERICK FERDINAND FERGUSON AND WAYLAND J. HAYES, JR.

WITH 20 TEXT-FIGURES

INTRODUCTION

The early history of the genus *Mesostoma* contains the illustrious names of Müller (1776), Ehrenberg (1835), and Schultze (1851). In the more contemporary literature the work of Luther (1904) is outstanding. The epic work of Graff (1913) presents the historical development of the genus in a very complete manner. Modern studies include the excellent work of Hyman (1938–39), and that of Ruebush (1939) upon the highly differentiated Tibetan species. The contributions of Kepner (1938) and Husted (1939) with their associates are noteworthy additions to a literature which is becoming marked by careful, thorough research not only on the gross anatomy but also on the cytology and physio-cytology.

Present work, however, is handicapped by the inaccessibility of some of the literature and the consequent vagueness of the taxonomic boundaries of the genus. There has for some time been a need for a concentration of all the literature references, all the valid species descriptions, and finally for a designation of all the species as valid, invalid, or transferred. This task has been undertaken in the present paper.* We have attempted to make the bibliography as complete as possible. The

* The authors wish to express their thanks to Drs. Ladley Husted and T. K. Ruebush for their stimulating criticism of this paper. An award of the Research Committee of the Virginia Academy of Science has aided materially in the production of this work.

references to each species are presented chronologically; those of the bibliography are alphabetized. An effort has been made to list every species which ever bore the generic name and to record its present standing. The separation of the valid species of *Mesostoma* has been accomplished by a key which is more or less artificial but is based on taxonomic features accepted by modern workers. In forming the key we have been driven to the conclusion that some species long in good standing depend, in fact, for their differentiation on characters of such transitory nature that no modern author will use them for distinguishing new species. The authors see no reason why characters not definite enough to distinguish new species should be good enough to separate old ones. Therefore, we have placed some previously accepted species in *species dubiae*, believing that no further attention should be paid to them, unless animals collected from the type locality of the supposed species be given a complete redescription and be found to exhibit specific differences from the species here accepted. A list of the acceptable and unacceptable taxonomic criteria in the genus *Mesostoma* has been placed at the end of the section on anatomy in this paper.

This paper does not in any sense undertake a complete discussion of the genus; it does attempt a complete outline. The essential features of structure are discussed and reference is made to interesting and special studies on development, cytology, etc. In the diagnosis of species usually only those characters are mentioned which are of some classificatory value.

CLASSIFICATION

(Bresslau 1933)
Class: Turbellaria
  Order: Rhabdocoela
    Sub-Order: Lecithophora
      Section: Typhloplanoidea
        Family: Typhloplanidea
          Sub-family: Mesostominae
            Genus: *Mesostoma* Ehrenberg 1835

(Meixner 1939)
Class: Turbellaria
  Order: Neorhabdocoela
    Sub-Order: Typhloplanoida
      Family: Typhloplanidae
        Sub-family: Mesostominae
          Genus: *Mesostoma* Ehrenberg 1835

GENUS DIAGNOSIS:—*Mesostoma* Ehrenberg 1835. Rhabdocoela with a rosulate pharynx attached to the ventral side of the enteron usually

slightly anterior to the middle of the body; without a distinct Russel-like organ although often with the anterior end capable of slight invagination and subsequent protrusion; without epidermal blind sac or ascus; with a single gonopore often combined with the mouth; with testes dorsal, usually medio-dorsal to the vitellaria; without vagina or ductus spermaticus; with bursa; with uteri paired and arising from the lateral or posterior surface of the genital atrium; without a connection between the reproductive organs and the enteron; with a pair of excretory stems opening into a common beaker combined with the mouth; eggs ectolecithal, usually of two sorts, the so called "winter" and "summer" eggs.

GENUS HISTORY

1776, *Planaria* (part.: *Planaria grossa, Planaria tetragona*), O. F. Müller in: Zool. Dan. Prodr., p. 221. / 1835, *Mesostoma* (part.: *Mesostoma grossum*), Ehrenberg in: Abh. Ak. Berlin, p. 244 (nota). / 1848, *Mesostomum* (part., excl.; *Mesostoma rostratum, Planaria personatum*) and *Schizostomum* (sp. un.: *Schizostomum productum*), O. Schmidt in: Rhabd. Strudelw. Süss. Wass., p. 40, 54. / 1882, *Mesostoma* (part.) L. Graff in Monogr. Turbell., v. 1, p. 285. / 1904, *Mesostoma*, Luther in: Z. wiss. Zool., v. 77, p. 145, 218. / 1909, *Mesostoma*, L. Graff in: Brauer, Süssw., v. 19, p. 118. / 1913, *Mesostoma*, L. Graff in: Das Tierreich, v. 35, p. 263–285. / 1933, *Mesostoma*, Bresslau in: Kükenthal und Krumbach "Handbuch der Zoologie". / 1939, *Mesostoma*, Meixner 1939.

DISTRIBUTION

Species of *Mesostoma* may be found in the fresh waters of Europe, Asia, and North America. Members of *Mesostoma lingua* are said to occur in European brackish waters as well as in fresh water. Representatives of *Mesostoma arctica* live in the fresh water pools of northern Manitoba, Canada (58° north latitude). Members of *Mesostoma ehrenbergii* are found in the fresh waters of Europe, Tomsk in Asia, and, it is said, North America and Trinidad. In opposition to this wide range of distribution some species, especially those recently described, are known only from restricted localities. Thus *Mesostoma virginiana* has yet been reported only from the fresh water swamps of Green County, Virginia, U. S. A. Ruebush has made an excellent study of three new Asiatic forms, *Mesostoma baoensis*, *Mesostoma togarmensis*, and *Mesostoma chusholensis*, from North India in the Tibetan area. Certainly no other *Mesostoma* and perhaps no other rhabdocoele has been collected at such an altitude (5200 m.) as *Mesostoma togarmensis*. It will be readily seen that species of *Mesostoma* possess a wide range of distribution both as

regards some individual species and as regards the genus. However, this distribution is not as universal as the literature on all the animals, which have at one time or another been given the name *Mesostoma*, might lead one to suppose.

ANATOMY

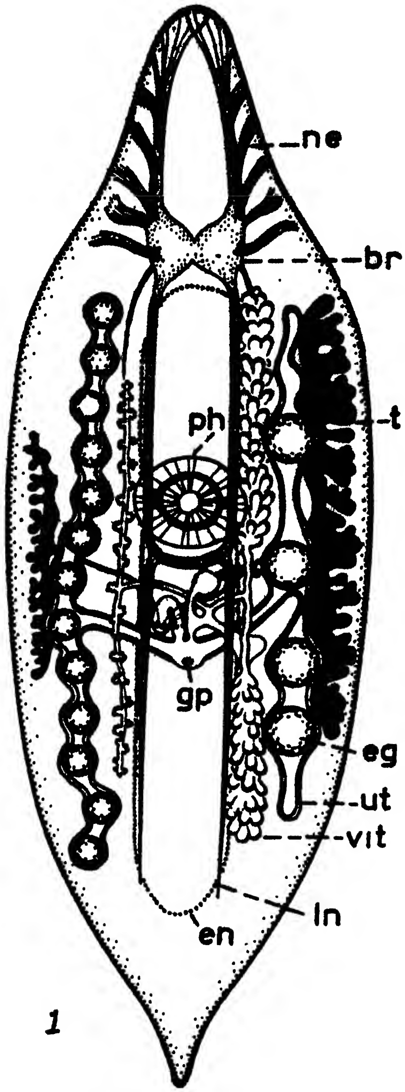
The size of the species of *Mesostoma* varies considerably. The American forms measure up to slightly over 5 mm., while the European forms may measure up to 15 mm. (*Mesostoma ehrenbergii*). This longest representative measures 4 mm. in width.

The shape of the worms varies from that of *Mesostoma ehrenbergii* (Fig. 1) with its elongate, anteriorly rounded and posteriorly pointed, spindle-like figure to the bulky body of *Mesostoma virginiana*. This latter animal has a somewhat oblanceolate contour with a broadly rounded posterior end. Further, the loose epidermis of *Mesostoma virginiana* forms extensive flaps or flanges along the sides of the body of the living animal. *Mesostoma ehrenbergii* does not possess these flaps.

LEGEND TO TEXT-FIGURES

ac = atrium copulatorium
al = anterior loop of protonephridia
bc = bursa copulatrix
br = brain
bs = blind sack
cs = cross stem
ct = cuticular part of penis
cvd = common vitello-duct
dc = ductus communis
e = eye
eg = egg
en = enteron
fc = flame cell
ga = genital atrium
gg = granule glands
gp = gonopore
iga = inferior genital atrium
k = nucleus
ln = longitudinal nerve
m = mouth
mg = combined mouth and gonopore
ms = main stem
= nerve
ne = nerve ending
od = oviduct
ov = ovary
p = penis
pg = pharyngeal glands
ph = pharynx
pn = protonephridium
pp = penis papilla
pv = protonephridial vesicle
rh = rhabdite
rk = retinula
rs = receptaculum seminis
sg = shell glands
stk = Stiftchenkappe
t = testis
ut = uterus
v = penis valve
vd = vas deferens
vdt = vitelloduct
vit = vitellaria
vg = vesicula granulorum
vs = vesicula seminalis
yf = yolk follicles

Body flaps, of course, result in a more or less angular cross section. It must be noted, however, that fixation and consequent contraction may



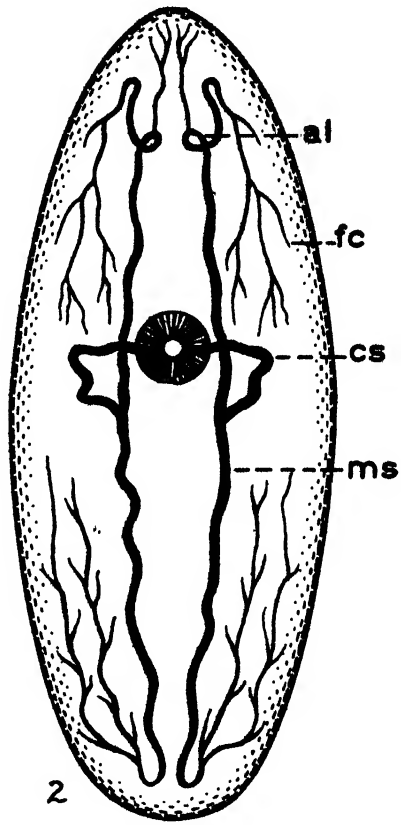


FIGURE 1. Dorsal view of gross anatomy of a *Mesostoma*. × ? After Graff, Vogt, Fuhrmann and Luther.

FIGURE 2. Dorsal view of protonephridial system of *Mesostoma ehrenbergi* (Focke). × ? After Leuckart 1852.

result in an angular cross section in animals which when living possess no flaps. This situation has been specially noted in the case of *Mesostoma arctica* by Hyman (1938). Doubtless this fixation reaction is

similar in many forms and the cross sectional contour of preserved material gives little hint of the true shape of the animal.

The movements of *Mesostoma* are confined either to a cumbersome swimming or to a creeping motion. The elephantine *Mesostoma virginiana* has not been seen to swim. When irritated some *Mesostoma* show quick flipping motions such as a fish might exhibit. This unusual phenomenon suggests a much higher degree of muscular and nervous development than is found in many other rhabdocoeles.

The color varies in shades of brown, gold and grey. The pigment is usually confined to the parenchyma but may also occur in the epidermal cells. The parenchyma may also contain oil droplets and a type of crystalloid is sometimes present. Some *Mesostoma* are colorless. Zoöchorellae are absent. Ruebush (1939) has commented on the fact that all the Tibetan species which he describes were collected from shallow water at great altitude and were deeply pigmented. He also observes that *Mesostoma lingua* in Europe is said to be more darkly pigmented when occurring in shallow water at great heights. *Mesostoma virginiana* might also be mentioned in this respect. Although the Blue Ridge mountains, where the animal is found, are not as high as those of Tibet, they do provide a strictly mountainous environment including cold water and a considerable diurnal variation in temperature. *Mesostoma arctica* found near the arctic circle in Canada at a very low altitude is also pigmented. The authors suggest that the relation of pigmentation to temperature and temperature variation should be investigated. It would be interesting to see if animals of the same strain would vary in shade of color if developed at different temperatures but at the same altitude.

The worms have a fine, even growth of cilia over the body, but lack modified ciliary structures such as spines, sensory hairs, or sensory hair tufts.

Paired eyes may be located somewhat dorso-posterior to the biganglionic "brain" or they may be lacking. In some (*Mesostoma virginiana*) the eyes are simple groups of pigment granules often connected by a median bridge. In others (Fig. 4) they possess those features, the ellipsoid, myoid, and rhabdoid, as delineated by Kepner and Stiff (1932) for *Macrostomum tuba.* While the eyes may appear black under low magnification, when enlarged they look reddish brown in most species or may even show a tinge of cherry-red (*Mesostoma rhynchotum*).

The central nervous system (Fig. 3) is composed of the bipartite "brain" and paired nerves. The "brain" gives off several pairs of

anterior nerves and two pairs of posterior-running, longitudinal nerve trunks. Of these trunks, the members of the more median pair are connected to a nerve ring in the pharynx and are further connected by a commissure just behind the pharynx. The more lateral pair of trunks lack commissures. The longitudinal trunks do not enlarge in the tail region as they do in some rhabdocoeles (*Macrostomum*). The anterior

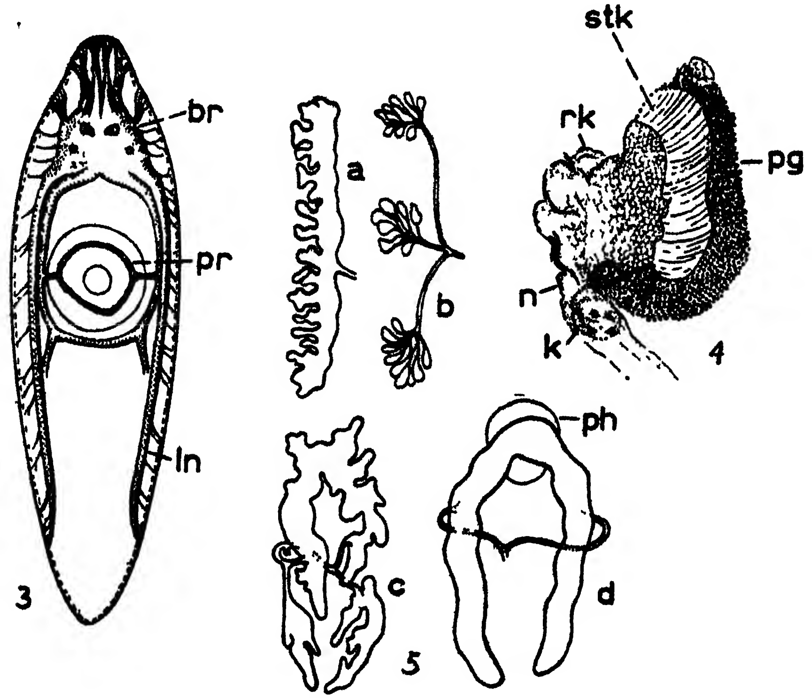


FIGURE 3. Dorsal view of nervous system of *Mesostoma lingua*. × ? After Luther 1904.

FIGURE 4. Section through the eye of *Mesostoma ehrenbergii* (Focke). × 960. After Luther 1904.

FIGURE 5. Diagrammatic representation of morphologic variation in the testes of *Mesostoma*. (a) *M. ehrenbergii*, (b) *M. tetragonum*, (c) *M. lingua*, (d) *M. craci*. × ? After Luther 1904.

rami are directed dorsally and ventrally in numerous strands which extend forward fan-wise to the tip and sides of the anterior end of the body. The rich nerve supply is correlated with the occurrence of various sense organs, a sensory snout, an anterior pit formed by epidermal invagination, or small pit-like sensory areas (Grubchenflecke) located antero-laterally, in different species.

The epidermal epithelium is a single-layered tissue composed of rather large polygonal cells 3 μ to 16 μ in height. Hyman states that the epidermis of *Mesostoma macropenis* is apparently syncytial. In mature animals a simple spheroidal nucleus lies near the center of each epithelial cell. In embryonic and therefore rapidly growing animals the nuclei of the epidermal cells are usually polymorphic.* The ciliary basal bodies have inwardly directed threads which produce a vertical striation in the outer layer of the plasma. The epithelium may be packed with short dermal rhabdites in its outer margin, or according to Hyman, in the basal portion of the cells of *Mesostoma arctica*. Rhammites may also occur sub-dermally over the general body surface and open to the exterior by short ducts through the epidermis. The erythrophilic, short (2 μ–18 μ) rhabdites are concentrated especially at the body extremities except at the points where the rhammite tracts open anteriorly. The elongate rhammites (sometimes exceeding 50 μ) show specific staining reactions and may either be distributed over the body or concentrated in anterior tracts or both. Numerous unicellular slime glands are located just under the muscular tunic and empty upon the external body surface.

The body wall is composed of an epidermis and two layers of non-striated muscle fibers. In the outer layer the elongate muscle cells are transversely disposed, whereas the cells of the inner layer lie parallel to the longitudinal axis of the body. These layers are usually, if not always, separated from the epidermis by a basal membrane sometimes of granular nature. The animals of this group are usually well provided with dorso-ventral and oblique muscles, especially in the anterior region where these muscles aid those of the body wall in controlling the mobile and often more or less protrusible anterior tip.

The parenchyma is of the type usually found in the Typhloplanidae.

The alimentary canal is simple and typical of that of the Lecithophora. The rosulate pharynx, lying usually just a little in front of the middle of the body, is well supplied with circular fibers and slender pyriform gland cells. The blindly ending enteron is composed of a very plastic, glandose epithelium. Numerous "Kornerkolben" are present. The system of tangential muscle threads mentioned above form a sort of basket work about the enteron. Digestion has been observed to be intracellular as well as extracellular.

The excretory system (Fig. 2) ably described by Leuckhart (1852) for *Mesostoma ehrenbergii*, appears to be of similar structure in the other

* Author's observation.

forms. Strongly developed, paired end stems empty laterally into the excretory beaker which opens through the mouth and constitutes a dilation of the pharyngeal pocket. The end stem is given off on each side near the middle of one of the pair of well developed, lateral branches. The pair of lateral branches extends for most of the body length, the ends breaking up into numerous smaller collecting branches which may closely embrace the gonads and yolk follicles and which bear at their tips flame cells.

The species of *Mesostoma* are hermaphroditic. Both genital systems communicate with the exterior through a common genital pore by way of a common genital atrium which may or may not be divided into superior and inferior genital atria. The mouth may, or may not, be combined with the common genital pore. Ruebush (1939) has observed that in young *Mesostoma chusholensis* the mouth and gonopore are clearly separate while in well matured animals the two openings enter a common chamber or depression on the body surface. Ruebush points out that this change is probably due to the growth of the copulatory organ and bursa which results in the forward inclination of the pharynx and the backward inclination of the genital complex. These displacements lead to the pulling up of the body wall between the two pores and consequently to the formation of a common chamber into which the mouth and gonopore open.

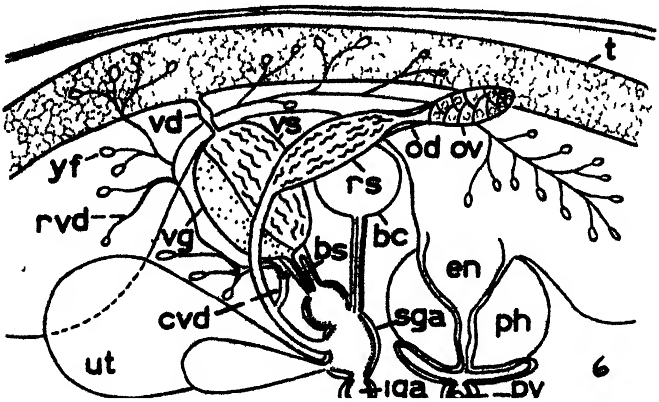
The male gonads (Fig. 5) consist of follicular or compact testes. These testes are always basicly paired as shown by the constant occurrence of paired vasa deferentia. In most species the testes of the two sides are themselves entirely separate. However, some species have the testes of the two sides anastomosing. This tendency reaches its highest development in *Mesostoma virginiana* where only small foramina remain between the fused, compact parts. The testes are essentially dorsal to the vitellaria, often being also more median than the vitellaria. Vasa deferentia, which communicate with a system of vasa eferentia, especially in the case of follicular testes, originate at about the mid-level of the testes and unite usually to produce a thin-walled ductus seminalis. This duct empties into the vesicula seminalis. The vasa deferentia may, however, empty separately into the vesicula seminalis. This spherical, muscular-walled organ is usually included in the tunic of the penis bulb which also houses the vesicula granulorum, yet in some forms described by Hyman the sperm sac occurs outside the bulb of the penis. The granule sac may be disposed dorsally or ventrally to the seminal vesicle within the bulbus. The bulbar male organ may have strong

walls composed of a thin outer layer of longitudinal muscles, two heavy layers of diagonal muscles, and a heavy inner layer of circular muscles (*Mesostoma togarmensis*). It may, however, lack this inner layer of circular muscle (*Mesostoma chusholensis*). The ductus ejaculatorius may also present a high degree of differentiation; Ruebush (1939, p. 59) states: "A cross-section of the ductus ejaculatorius shows an outer layer of circular muscles, a thick middle region which Luther (1904) has called 'epitheliales Plasma' and an inner, strongly cuticularized tube." This cuticular ductus may measure up to 280 μ in length (*Mesostoma togarmensis*). A small but none the less conspicuous blind sac is housed by the penis papilla or stalk in *Mesostoma virginiana*. The papilla in some forms lies in a well defined atrium copulatorium which is a dorsal dilation of the superior part of the genital atrium.

Mature sperm cells which may be found in the vasa deferentia, in the dilation of the ductus seminalis ("false vesicula seminalis"), or in the vesicula seminalis are elongate thin threads. They measure up to 230 μ (*Mesostoma lingua*) and possess, at least in the forms carefully studied in this respect, paired setae.

The organs composing the female reproductive system (Fig. 6) are more uniform in their morphology than are those of the male system. The ovary is a small, anteriorly directed, club-shaped gonad consisting of small lenticular oögonia and at times, larger and more distal oöcytes. In *Mesostoma virginiana* some interesting correlations between the respective conditions of the ovary and certain epithelia have been observed. The ovary may present two physiological phases. At times there are only lens-shaped oögonia; at other times a large oöcyte is to be found at the mouth of the oviduct. Associated with these ovarian phases are certain changes in the cells of the oviduct and in the epithelial cells of the receptaculum seminis. When the ovary contains only oögonia the oviduct epithelium is composed of slender, tall cells whose nuclei are club-shaped. On the other hand, when an oöcyte is present in the ovary, the epithelium of the oviduct becomes stout, its cells becoming quite as wide as high and apparently forming a syncytium while the nuclei become greatly enlarged. When the ovary contains only oögonia, the cells covering the outside of the receptaculum seminis and covering the muscles of that organ are flattened so that they form a heavy permanent layer. In comparison, when an oöcyte lies within the ovary, these peritoneum-like cells become altered so that instead of being flattened, they are stout and columnar. Morphologically the oviduct is short, slender, and rather thick-walled. The receptaculum seminis may be a simple dilated portion of the female

tract or, more rarely, it may be a discrete thin-walled sac appended to the tract near the oviduct.



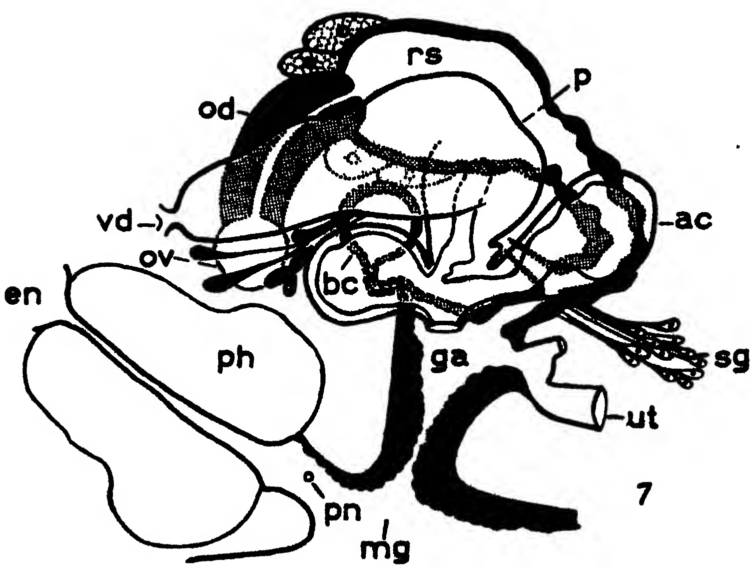


FIGURE 6. Diagrammatic lateral optical section of sex apparatus of *Mesostoma virginiana.* K., F., and S. × 33. After Kepner, Ferguson and Stirewalt 1938.
FIGURE 7. Diagrammatic left lateral optical section of sex apparatus of *Mesostoma arctica* Hyman. × ? After Hyman 1938.

The paired uteri may have a single uterine pore opening into the basal part of the common genital atrium, or they may empty separately. They may extend latero-posteriorly and thus exist only behind the

gonopore, or they may have a $\vdash$-shaped configuration and thus lie both anterior and posterior to the gonopore. It seems that, in those species where the uteri are posterior, the uterine wall is thin; while in those species where the uteri are $\vdash$-shaped, the uterine wall is thicker.

Eggs are of two types; there are small, thin-shelled, yolk-poor summer eggs and larger, hard-shelled, yolk-laden winter eggs. The former, it is said, may be self fertilized during the early development of those animals which are the first to hatch from winter eggs in early spring. The summer eggs develop within about 12 days. Embryos of good size have been observed to reach freedom by passing through the uterine wall, into the parenchyma, and out through the body wall of the mother. Undoubtedly this is an abnormal method of escape for the young animal. Winter eggs are liberated via the gonopore or, more usually, in great numbers when the animal dies. It is not known whether the animal may overwinter under natural conditions in a not too rigorous climate. It is sure that where conditions are unfavorable, the animals overwinter in the hard-shelled resting egg stage. It is also known that these same species may, under carefully regulated laboratory conditions, be made to live through many generations over a period of at least two years without the production of winter eggs and the consequent interpolation of a resting stage. Bresslau (1903 and 1904) has made noteworthy contributions to the cytology and embryology of these forms.

Vitellaria may be either follicular or papillose and are usually quite extensive. There is a union of all the vitello-ducts into a single main duct which enters the ductus communis below the receptaculum seminis and near the entrance of the ductus communis into the genital atrium when the latter is spatially differentiated.

The female accessory organ, the bursa copulatrix, has a most variable structure. It may be merely a thin-walled evagination of the dorsal wall of the genital atrium. It may be more complex, being provided with a thin-walled, highly distensible, slightly muscular, sac-like portion joined by a narrow, highly muscular stalk to the dorsal wall of the genital atrium. This complicated structure may, or may not, possess a cuticular lining. The stalk may be long or short and may be supplied with sphincters which surpass in strength the already strong circular muscles which constitute the walls of the stalk.

The common genital atrium may be subdivided into superior and inferior atria (Fig. 6) separated by a sphincter. The dorsal portion of the atrium may have short lateral diverticula. A space, within which

the penis papilla lies and is more or less definitely cut off from the rest of the atrium, is sometimes designated the atrium copulatorium. There is some degree of variance in the points at which the ducts and tracts of the two systems enter the atrium in the different forms. The bursa copulatrix opens dorsally into the atrium. The copulatory organ and the ductus communis open into the upper portion of the atrium, but either may be the more dorsal; the difference being correlated, it seems, with the development of the atrium copulatorium. Probably the most striking difference in the point of entrance occurs in the uteri of different species. The uteri may enter by a common pore or paired pores. In *Mesostoma virginiana* the uteri enter the lower portion of the superior atrium while in *Mesostoma baoensis* the uteri enter the inferior atrium. In all species the point of entrance of the uteri is more ventral than are the other openings into the atrium.

Because some of the species of *Mesostoma* have unusually long chromosomes that exhibit interesting non-association phenomena and because all the species which have been studied in this respect have easily observable chromosomes, the genus presents excellent cytological material. Reference is made to the valuable works of Husted (1939), Husted and Ruebush (1940) and Valkanov (1938) upon chromosome morphology in *Mesostoma*. We note with regret that this latter comprehensive work has not as yet been translated into an acceptable language. The following authors have made studies upon these chromosomes: Ruebush (1939) on *Mesostoma chusholensis*, 2N = 8, N = 4; Schneider (1883) on *Mesostoma ehrenbergii*, 2N = *ca.* 7; Bresslau (1904) on *Mesostoma ehrenbergii*, 2N = 10, N = 5; Luther (1904) on *Mesostoma ehrenbergii*, N = 5; Voss (1914) on *Mesostoma ehrenbergii*, 2N = 10, N = 5; Husted, Ferguson, and Stirewalt (1939) on *Mesostoma ehrenbergii* var. *wardii*, 2N = 8, N = 4; Luther (1904) on *Mesostoma lingua*, N = 3; Valkanow (1938) on *Mesostoma rhynchotum*, 2 N = 16, N = 8; Ruebush (1939) on *Mesostoma baoensis*, 2N = 8, N = 4; on *Mesostoma togarmensis* 2N = 8, N = 4; Kepner, Ferguson and Stirewalt (1938) on *Mesostoma virginiana*, 2N = 8, N = 4; Ruebush (1938) on *M.* sp. 2N = 6, N = 3.

Ruebush (1940) has indicated the desirability of using *Mesostoma ehrenbergii* var. *wardii* (collected in Genesee River between lower falls and Lake Ontario and sold by Ward Biological Supply Company, Rochester, New York) as the Turbellarian type in teaching. This large translucent form readily displays its anatomy, showing especially fine flame cells and chromosomes (up to 32 μ in length!).

TAXONOMIC CRITERIA

Anatomical features generally considered of classificatory value by modern workers include: the presence and form of the cuticular lining of the ductus ejaculatorius; the form of the penis itself, whether it be ovoid to pear-shaped, or retort-shaped, and the development of its muscular layers; the relationship of the vesicula seminalis and the vesicula granulorum; the nature of the testes whether definitely compact or follicular; the form, musculature, and lining of the bursa copulatrix; the form of the uteri; the configuration of the genital atrium, its size, division, and musculature, and the number and morphology of the chromosomes.

Recently Hyman (1938, p. 1, 2) and Ruebush (1939, p. 61, 62, 64) have mentioned those features of *Mesostoma* which must be used with great caution in taxonomic work. The reasonableness of these authors' statements is evident to anyone who has ever worked with *Mesostoma*. The highly variable features include: the shape of the body and its cross-sectional configuration; the development of the protrusible anterior tip of the body; the pigmentation; the presence or absence of eyes; the mouth gonopore relationship; and the size and degree of anastomosis of the testes.

KEY TO THE SPECIES OF MESOSTOMA

1	(18)	Penis without cuticular lining of the ductus ejaculatorius	2
2	(5)	Vesicula seminalis separated from the vesicula granulorum by a constriction	3
3	(4)	Uteri extending posteriorly from the common genital atrium	*M macroprostatum*
4	(3)	Uteri T-shaped.	*M. macropenis*
5	(2)	Vesicula seminalis and vesicula granulorum distinct but both contained in the bulbus of the penis	6
6	(13)	Uteri extending posteriorly from the common genital atrium, not T-shaped	7
7	(10)	Atrium divided	8
8	(9)	With an atrium copulatorium but without a division of the atrium into superior and inferior parts	*M. canum*
9	(8)	Without an atrium copulatorium but with the common genital atrium divided by a sphincter into an inferior part receiving the uteri and a superior part receiving all the other sex organs	*M. baoensis*
10	(7)	Atrium not divided in any way	11
11	(12)	Without a cuticular lining of the common genital atrium	*M. armeniacum*
12	(11)	With the genital atrium covered by a cuticular membrane	*M. platycephalum*
13	(6)	Uteri T-shaped	14

14 (15) Testes with a small posterior and a large anterior anastomosing portion .... *M. lingua*
15 (14) Testes follicular or lobate, not anastomosing 16
16 (17) Chromosome number N = 5, 2N = 10 .... *M. ehrenbergii*
17 (16) Chromosome number N = 4, 2N = 8 .... *M. ehrenbergii wardii*
18 (1) Penis with a cuticular ductus ejaculatorius 19
19 (20) Vesicula seminalis separated from the vesicula granulorum by a constriction .... *M. arctica*
20 (19) Vesicula seminalis and vesicula granulorum distinct but both contained within the bulbus of the penis 21
21 (44) Without a blind sac in the penis papilla 22
22 (23) Cuticular ductus ejaculatorius ending distally in a crown of fine points or spines .... *M. nigrorostrum*
23 (22) Cuticular ductus ejaculatorius without spines, either a simple tube or a cuticular membrane covering both the inside and outside of the papilla 25
24 (27) Ductus ejaculatorius a thin cuticular membrane covering both the inside and outside of the penis papilla 25
25 (26) Uteri simple extending posteriorly .... *M. punctatum*
26 (25) Uteri T-shaped .... *M. chromobractrum*
27 (24) Ductus ejaculatorius a simple tube 28
28 (35) Cuticular ductus ejaculatorius less than 100 μ in length 29
29 (34) Bursa copulatrix without a cuticular lining 30
30 (33) Entire length of the ductus ejaculatorius with a cuticular lining 31
31 (32) Eyes present; bursa copulatrix without a well developed stem .... *M. productum*
32 (31) Eyes lacking; bursa copulatrix with a well developed stem .... *M. columbianum*
33 (30) Cuticle present only in the distal part of the ductus ejaculatorius ... *M. bologoviense*
34 (29) Bursa copulatrix with a cuticular lining .... *M. rhynchotum*
35 (28) Cuticular ductus ejaculatorius promiment, more than 100 μ long 36
36 (43) Cuticular ductus ejaculatorius less than 200 μ long 37
37 (38) Uteri T-shaped .... *M. tetragonum*
38 (37) Uteri simple, extending posteriorly 39
39 (40) Atrium copulatorium set off by a sphincter .... *M. mutabile*
40 (39) Atrium copulatorium not developed 41
41 (42) Penis retort-shaped; the cuticular lining widened in entering the genital atrium .... *M. craci*
42 (41) Penis pear-shaped; the cuticular lining of the ductus ejaculatorius gradually narrowed distally .... *M. chusholensis*
43 (36) Cuticular ductus ejaculatorius over 200 μ long .... *M. togarmensis*
44 (21) With a blind sac in the penis papilla .... *M. virginiana*

SPECIES DIAGNOSIS TO VALID FORMS

Mesostoma arctica Hyman 1938, *Mesostoma arctica*, Hyman in: American Museum Novitates, No. 1005. / 1939, *Mesostoma arctica* Hyman in:

American Midland Naturalist, v. 21, p. 646, 647. / 1939, *Mesostoma arctica* Hyman in: American Midland Naturalist, v. 22, p. 630.

Body anteriorly blunt (Fig. 7) with deep terminal depression, the diameter of the body diminishing gradually from the anterior end to a slender tail; color greyish brown or brown; with rhabdites in the basal portion of the epidermal cells and with rhammites present in the epidermis and in anterior tracts; general form of excretory system typical; mouth and gonopore combined; testes follicular, extensive, dorsal; vesicula seminalis separated from the large vesicula granulorum by a constriction, the vesicula granulorum in turn distinct from a special terminal portion of the penis bulb which bears the penis papilla; penis papilla bearing a cuticular ductus ejaculatorius and projecting into the genital atrium; female genital system regular; paired uteri extending latero-posteriorly; bursa copulatrix with a narrow stalk; superior region of the genital atrium with a large diverticulum lying to each side of the penis papilla; body length up to 5 mm.; habitat: fresh water pools near Churchill, Manitoba, Canada; type: catalog no. 263, American Museum of Natural History.

M. armeniacum Plotnikow 1906, *M. a.*, Plotnikow in: Zool. Jahrb. Syst., v. 23, p. 396, pl. 22, f. 1, 2. / 1938, *M. a.*, Kepner, Ferguson, and Stirewalt in Zool. Anz., v. 121, p. 312. / 1939, *M. a.*, Ruebush in: Zool. Anz., v. 126, p. 65.

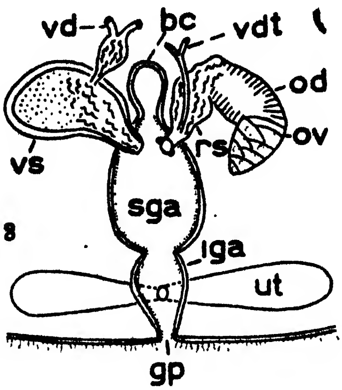
Body elongate, widest at the beginning of the second body third in the region of the copulatory organs; both ends of the body broadly rounded, the posterior end more gradually tapered than the anterior; black pigment granules present in the mesenchyme especially in front of the pharynx, between the eyes, and between the follicles of the vitellaria; black, half-moon-shaped eyes provided with lenses and placed equidistant between the pharynx and the anterior end; pharynx near the end of the first body third; gonopore surrounded by a ring of glands; testes small; vasa deferentia provided just behind the gonopore with "false vesicula seminalis;" vesicula seminalis pear-shaped, without a cuticular ductus ejaculatorius; receptaculum seminis a widening of the germ duct; vitellaria extensive, surrounding the enteron on all sides; chromosomes unknown; body length 1.2 mm.; habitat: Goktscha-Sea, Russia.

Mesostoma baoensis new name,* *Mesostoma lingula* sub-sp. *baoensis* Ruebush 1939, *M.l.b.*, Ruebush in: Zool. Anz., v. 126, 3/4, p. 53–57, 58–63, 65, 66, f. 2, 3.

* In the author's opinion this animal deserves the rank of species and is herein renamed *Mesostoma baoensis*.

Body bluntly rounded anteriorly (Fig. 8), widest in the pharyngeal region, tapering to a point posteriorly; pigment dark brown, parenchymal; eyes present; rhabdites present in cellular epidermis and

8



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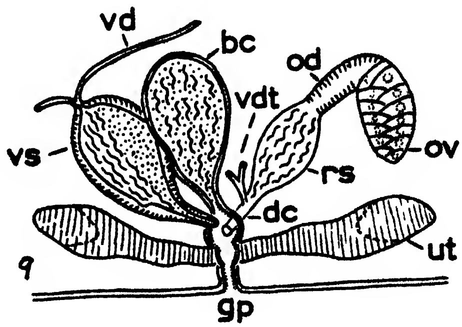
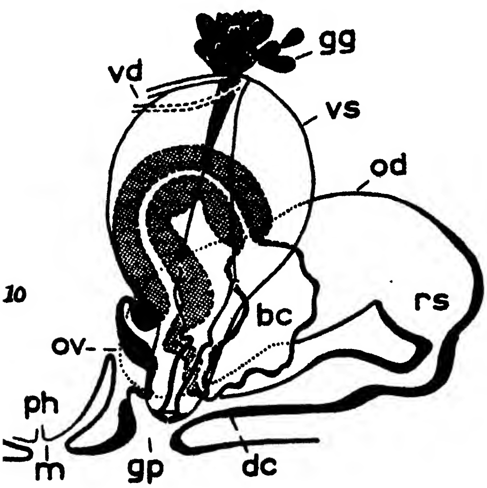


10



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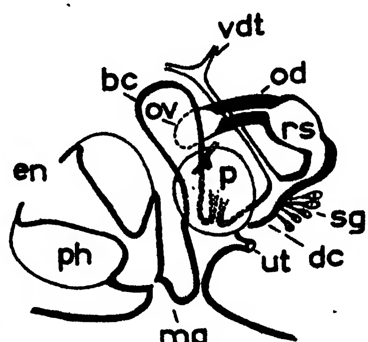


FIGURE 8. Diagrammatic anterior optical section of sex apparatus of *Mesostoma baoensis* (Ruebush) F. and H. × 133. After Ruebush 1939.

FIGURE 9. Diagrammatic anterior optical section of sex apparatus of *Mesostoma chusholensis* Ruebush. × 45. After Ruebush 1939.

FIGURE 10. Diagrammatic right lateral optical section of sex apparatus of *Mesostoma columbianum* Hyman. After Hyman 1939.

FIGURE 11. Diagrammatic left lateral optical section of sex apparatus of *Mesostoma craci*. O. Schmidt. × 47. After Luther 1904.

rhammiten in anterior tracts; excretory system undescribed; mouth and gonopore separate; testes large, dorsal, anastomosing anteriorly and posteriorly; penis bulb pyriform without an inner layer of circular

muscles, containing both the vesicula seminalis and the vesicula granulorum; ductus ejaculatorius short, not cuticular, superior and inferior divisions of the common genital atrium separated by a sphincter; bursa copulatrix a simple, short evagination of the dorsal wall of the superior genital atrium; female genital system regular; receptaculum seminis a dilated, thin-walled portion of the oviduct cut off from the superior genital atrium by a sphincter; paired uteri extending latero-posteriorly from their common opening into the inferior genital atrium; chromosomes: N = 4, 2N = 8; body length up to 2.5 mm.; habitat: pond near Bao in Western Tibet (elevation 4616 m.).

M. bologoviense Plotnikow 1900, *M. sp.*, Plotnikow in: Trudui St. Peterb. Obsch., v. 31–1, p. 341 (nr. 3). / 1906, *M. bologoviense*, Plotnikow in: Ber. Süsswassert. Naturf.-Ges. St. Petersb., v. 2, p. 3, 10, pl. 2, f. 3.

Body very elongate with the front end somewhat flattened; body colorless and transparent; long, thin rhammites present in the rodways; eyes with sharply set off black pigment cups sometimes connected by a loose pigment bridge; pharynx opening at the beginning of the second body third; gonopore opening at half the body length; testes elongate oval, posterior to the gonopore; vasa deferentia arising from the median surface of the anterior half of the testes, each vas with a small "false vesicula seminalis"; penis bulb pear-shaped, the ductus ejaculatorius short and tubular and provided in the distal half with a cuticular lining; bursa large and retort-shaped; receptaculum seminis spherical, cut off from the germ duct by a narrow stem; vitellaria small, smooth, reaching anteriorly to the region of the eyes; with at one time only a single concavo-convex egg present; chromosomes unknown; body length up to 1.5 mm.; habitat: Bologoje, Russia (Twer).

M. canum Weiss 1909, *M. c.*, A. Weiss in: Fauna SW. Australia. v. 2, p. 403. / 1910, *M. c.*, Weiss in: Z. wiss. Zool., v. 96, p. 337, 339, pl. 14, f. 3–6. / 1938, *M. c.*, Kepner, Ferguson and Stirewalt in: Zool. Anz., v. 121, p. 313. / 1939, *M. c.*, Ruebush in Zool. Anz., v. 126, p. 55.

Body of typical form known only from fixed specimens; brown pigment granules arranged in a reticulum in the mesenchyme especially dorsally; rhabdites, filling almost the entire height of the cells, abundant in the epidermis; peg-shaped or pestle-shaped rhammites present over the whole body and especially abundant along the sides and in the anterior rodways; mouth and gonopore combined, anterior to the body middle; oesophagus funnel-form; enteron sac-like, extending the entire body length; eyes small, black, and set close together, the length about 18 μ; testes dorsal, extending from the brain to the third body fourth,

similar in form to those of *M. ehrenbergii*; vasa deferentia opening separately into the upper part of the spherical vesicula seminalis which opens by a small papilla into the atrium copulatorium; female system typical, the receptaculum seminis a dilation of the germ duct, the germarium egg-shaped; bursa copulatrix round and strongly made, provided with a stem; vitellaria elongate, papillose, opening into the ductus communis opposite the shell glands; body length about 4 mm., width about 2 mm.; habitat: stream near Broom Hill, Southwest Australia.

M. chromobractrum M. Braun 1885, *M. c.*, M. Braun in: Arch. Dorpat. Ges., ser. 2, v. 10, p. 157, pl. 3, f. 18–20, pl. 4, f. 4. / 1902, *M. cyathus*, Dorner in: Schr. Ges. Konigsb., v. 43, p. 17, pl. 1, f. 2. / 1904, *M. chromobractrum*, Luther in: Z. wiss. Zool., v. 77, p. 227. / 1907, *M. c.*, L. Graff in: Brauer. Süssw., v. 19, p. 120, f. 227. / 1938, *M. c.*, Kepner, Ferguson and Stirewalt in: Zool. Anz., v. 121, p. 312.

Body of typical form, cross-section round in free swimming animals but quadrangular in contracted or fixed specimens; color brown as a result of pigment cells in the mesenchyme from which small, brown, 6 μ long pigment rods enter the epithelium filling every cell with from 30 to 90 pieces; long thread-like rhammites present in the anterior rodways as well as 3 to 7 in each epithelial cell of rest of the body; eyes close together, sometimes connected by a pigment bridge, nearer the anterior end than in *M. lingua;* pharynx pigmented, anterior to the body middle; excretory system typical; gonopore directly behind but separated from the mouth; testes large, follicular, dorsal, anastomosing for a short distance about the middle of the body, extending from the eyes to near the posterior end of the body; copulatory organ thin-walled, pear-shaped, slightly flattened on one side, receiving at the proximal end the vasa deferentia and more distally the granule glands; ductus ejaculatorius lined by cuticle which continues as a cuticular membrane over the end of the penis; copulatory organ and atrium provided with many pigment cells; bursa kidney-shaped, provided with a long muscular stem; vitellaria follicular; receptaculum seminis a distension of the germ duct; resting eggs concavo-convex or plano-convex, as much as 228 μ wide, brown in color, numbering in one instance 51 in a single animal; length up to 7 mm.; habitat: fresh water pools East Prussia and Livland.

Hofsten (1907, p. 459) considers this species identical with *M. lingua*, but the presence of a cuticular lining of the ductus ejaculatorius in the one and its absence in the other, as well as other differences, would seem to show that the two species are separate.

Mesostoma columbianum Hyman 1939, *Mesostoma columbianum*, Hyman in: American Midland Naturalist, v. 22, p. 629–636.

Body short, plump with rounded ends (Fig. 10), said to be dark grey; anterior end with a slightly pigmented, histologically set off area in each side thought to be sensory; cellular epithelium slightly and the ventral portion of the parenchyma more definitely pigmented; rhabdite tracts present as well as dermal rhabdites; eyes wanting; protonephridial opening typical; gonopore separate from mouth; testes follicular, dorsal; vesicula seminalis small, contained in the penis bulb, and displaced to the side by the highly developed, centrally placed granule channel; penis papilla with a cuticular ductus ejaculatorius; female system regular; vitellaria follicular, lateral bursa copulatrix with a muscular stalk cut off from the atrium by a sphincter; paired uteri extending latero-posteriorly; chromosomes unknown; body length 1.3 mm.; locality: pond, Chain Bridge, District of Columbia, U. S A.

Mesostoma chusholensis Ruebush 1939, *Mesostoma chusholensis* Ruebush in: Zool. Anz., v. 126, 3/4, p. 60–64, 66, f. 6.

Body bluntly rounded anteriorly (Fig. 9), widest at the pharyngeal region, tapering to a point posteriorly; rhabdites present in cellular epithelium and rhammites in anterior tracts; eyes diffuse, closely set; excretory system unknown; mouth and gonopore separate though closely approaching one another in completely mature specimens; dorso-lateral testes anastomosing posteriorly only; penis bulb pyriform with a thin outer longitudinal, two median diagonal, and an inner circular layer of muscles; ductus ejaculatorius a cuticular tube (165 μ); female genital system regular; vitellaria with follicular anterior and posterior divisions; uteri extending latero-posteriorly from separate pores into the small undivided genital atrium; bursa copulatrix provided with a highly developed musculature and divided into a narrow stalk and a distensible sac; chromosomes: N = 4, 2N = 8; body length up to 3.2 mm.; habitat: pond near Chushol, south of Panggong Tso, Tibet.

M. craci O. Schmidt 1848, *M. tetragonum* (part.), O. Schmidt in: Rhabd. Strudelw. süss. Wass., p. 44. / 1858, *M. craci*, O. Schmidt in: Denk. Ak. Wien, v. 15, p. 27, pl. 2, f. 1–5. / 1862, *Turbella c.*, Diesing in: SB. Ak. Wien, v. 45–1, p. 221. / 1882, *Mesostomum c.*, + *M. tetragonum*, L. Graff, Monogr. Turbell., v. 1, p. 298; p. 295, pl. 4, f. 17–20, textf. 1. / 1885, *Mesostoma c.*, M. Braun in: Arch. Dorpat. Ges., ser. 2, v. 10, p. 164, pl. 1., f. 5; pl. 4, f. 1, 2. / 1890, *M. c.*, Böhmig in: Z. wiss. Zool., v. 51, p. 57, 71, 101, pl. 21, f. 13. / 1900, *M. sp.*, Sabussow in: Traudui Kazan Univ., v. 34-V, p. 24, 184. / 1902, *M. craci*, Dorner in:

Schr. Ges. Konigsb., v. 43, p. 19. / 1903, *M. oscari*, L. Graff. Turbell. Paras. Wirte, p. 57 (this is equivalent to *tetragonum* of Graff and not of Hallez). / 1904, *M. craci*, Luther in: Z. wiss. Zool., v. 77, p. 241, pl. 1, f. 33, 44; pl. 4, f. 19, 21; pl. 5, f. 34, 40; pl. 6, f. 3, 4, 13; textf. 9-H, 12. / 1904, *M. c.*, Markow in: Trudui Kharkov. Univ., v. 29, p. 39. / 1906, *M. craci*, Brinkmann in: Vid. Meddel., v. 58, p. 96, pl. 8. / 1909, *M. c.*, L. Graff in: Brauer, Süssw., v. 19, p. 123, f. 133H, 229. / 1911, *M. c.*, Meixner & Muth in: Rec. Ind. Mus., v. 6, p. 62, pl. 2. / 1939, *M. c.*, Ruebush in: Zool. Anz., v. 126, p. 49, 60 and 64.

Body elongate (Fig. 11), not more than one fifth as wide as long, pointed at both ends, the anterior end rounded in contracted animals; resting animals round in cross-section; swimming, contracted, or fixed animals quadrangular in cross-section; with the ventral side concave and a ring-shaped constriction at the body middle when suspended in water by a slime thread; mesenchyme colored by a brownish pigment; epithelial cells filled by rhabdites about 8 μ long, the cells at the anterior end of the body almost twice as high as those of the rest of the body; rhammites up to 48 μ long, concentrated in the anterior rodways; slime glands abundant on the ventral surface; eyes dark brown, elongate, placed close together, parallel to the mid-line, and sometimes anastomosing; mouth at or slightly behind the middle of the body, pharynx communicated to the enteron by a short eosophagus; gonopore opening into a slight depression behind the mouth; paired testes lying close together over the enteron and anastomosed over the pharynx to form a horse shoe shape; vasa deferentia arising dorso-laterally and uniting just before entering the vesicula seminalis; bulbus of the penis strongly muscled with one external layer of longitudinal muscle, two layers of oblique muscle, and an inner layer of circular muscle, the bulbus receiving somewhat to the side of the tip the united vasa deferentia and below that the granule glands; vesicula seminalis and vesicula granulorum lying beside one another within the penis bulb; ductus ejaculatorius lined by a cuticular tube about 166 μ long, funnel-shaped at the proximal end and provided with a sharp terminal enlargement distally; sperm thread-like with two flagella near one end; bursa retortform, provided with a stem, placed anterior to the penis bulb; female system regular; receptaculum seminis a much swollen distension of the germ duct; vitellaria follicular, the follicles finger-like and almost always provided with stems; uteri simple, posteriorly directed sacs; winter eggs concavo-convex, thin-shelled, brick red or reddish brown in color, .52–.56 mm. broad, with as many as 20 found in a single animal; length

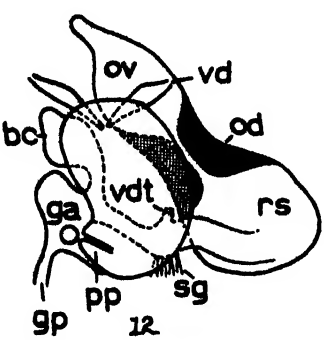
up to 12 mm. seldom over 15 mm.; habitat: same as *M. ehrenbergii* in Europe—Germany, Austria (from Krakau to Lesina), Russia (from Solowetzk to Kasan and Charkow)—reported by Meixner from Mangtsa Tibet about 4,800 m.

Mesostoma ehrenbergii (Focke) Schmidt 1848. / 1789, *Planaria tetragona* (part.), Abildgaard in: O. F. Müller, Zool. Dan., ed. 3, v. 3, p. 42, f. 106, f. 5 (Abbild.). / 1836, *Planaria ehrenbergii* (part.), W. Focke in: Ann. Wien. Mus., v. 1, II, p. 191, t. 17, f. 1–8, 11, 12, 15–19. / 1848, *Mesostomum ehrenbergii*, O. Schmidt in: Rhabd. Strudelw. süss. Wass., p. 47, t. 4, f. 9. / 1852, *Mesostomum ehrenbergii*, R. Leuckart in: Arch. Naturg., v. 181, p. 234, t. 9 (Anat.). / 1858, *Mesostomum ehrenbergii*, O. Schmidt in: Denk. Ak. Wien., v. 15, p. 32, t. 3, f. 3, 4. (Kopul.-Org.). / 1862, *Turbella ehrenbergii*, Diesing in: SB. Ak. Wien, v. 45, I, p. 220. / 1874, *Mesostomum ehrenbergii*, L. Graff. in: Z. wiss. Zool., v. 24, p. 146, t. 15, 16 (Anat.). / 1878, *Mesostomum ehrenbergii*, Metchnikoff in Zool. Anz., v. I, p. 387–390. / 1879, *Mesostomum ehrenbergii*, Hallez in: Trav. Wimereux Fasc. II. / 1883, *Mesostomum ehrenbergii*, Ant. Schneider in Das Ei, p. 17–21, 54–56, t. 3, f. 1–23 (Ei, Sperma). / 1885, *Mesostomum ehrenbergii*, C. Vogt (& Yung), Lehrb. vergl. Anat., v. 1, p. 247 (Anat., Histol.). / 1888, *Mesostoma ehrenbergii*, J. Kennel in Zool. Jahrb., v. 3, p. 447–486. / 1892, *Mesostoma ehrenbergii*, Ott, H. N. in: Journ. Morph., Vol. VII (3), pp. 263–304, pl. XIV, XVIII. / 1893, *Mesostoma ehrenbergii*, F. Wagner in: Biol. Centralbl., v. 13, p. 291–294. / 1894, *Mesostoma ehrenbergii*, Fuhrmann in: Rev. Suisse Zool., v. 2, p. 239, t. 10, t. 11 (Gehirn, Auge). / 1895, *Mesostoma ehrenbergii*, C. Wesenburg-Lund in: Vidensk. Medd. Naturhist. Foren. / 1895, *Mesostoma ehrenbergii*, A. Garbini in: Bull. Mus. Zool. Torino, V. 10, no. 198, p. 2, 6. / 1896, *Mesostoma wardii*, W. M. Woodworth in: Bull. Mus. Harvard, v. 29, p. 241, f. 2. / 1897, *Mesostoma wardii*, W. M. Woodworth in: Bull. Mus. Harvard, v. 30, p. 11, f. 6 (Abbild.). / 1903, *Mesostomum ehrenbergii*, Bresslau in: Verh. D. Zool. Ges., v. 13, p. 126, f. 1, 2 A (Eier). / 1904, *Mesostomum ehrenbergii*, Bresslau in: Z. wiss. Zool., v. 76, p. 220, 286 t., 14–16, tf. I, II (Entw.). / 1904, *Mesostoma ehrenbergii*, Luther in Z. wiss. Zool., v. 77, p. 227, t. 1, f. 1, 5, 9–11, 17, 18, 28–30; t. 2, f. 5, 7, 12–14, 16–25; t. 3, f. 9, 19–22, 25, 29; t. 4, f. 3–9, 17; t. 5, f. 3–11; t. 6, f. 12; tf 1, 9 D (Anat. Histol.). / 1904, *Mesostoma ehrenbergii*, Sekera in: Zool. Anz., v. 28, p. 233 (Biol.). / 1909, *Mesostomum ehrenbergii*, E. C., in Zool. Anz., Vol. 34, p. 257. / 1909, *Mesostoma ehrenbergii*, L. Graff in: Brauer, Süssw., v. 19, p. 121, f. 133 B., 201, 202, 228. / 1912, *Mesostoma ehrenbergii*, Hofsten in:

Rev. suisse de Zool., v. 20, Nos. 12 & 13. / 1913, *Mesostoma ehrenbergii*, L. Graff in: Das Tierreich, II. Rhabd. p. 273. / 1914, *Mesostoma ehrenbergii*, von Voss, H., in: Arch. f. Zellforsch., vol. 12, 159–194. / 1916, *Mesostoma ehrenbergii*, Ball, S. C., in: Journ. Morph., vol. 27, pp. 453–559. / 1918, *Mesostoma ehrenbergii*, Higley, R., in: Illinois Biol. Monogr., vol. 4, 195–288. / 1920, *Mesostoma ehrenbergii*, Harvey, E. B., in: Journ. Morph. and Physiol., vol. 34, 1–67. / 1933, *Mesostoma ehrenbergii*, Bresslau, E., in: Handbuch der Zool., II, pt. I, pp. 19–320. / 1935, *Mesostoma ehrenbergii*, Senn., H. A., in: Zool. Anz., vol. III, p. 47, 1935. / 1936, *Mesostoma ehrenbergii*, Phillips, H. M., in: Zool. Anz., vol. 114, p. 323. / 1936, *Mesostoma ehrenbergii*, Southern in: Proc. Roy. Irish Acad., V, XLIII, Sect. B., No. 5, pp. 56–57. / 1937 / 38, *Mesostoma ehrenbergii*, Valkanov in: Jarhb. Univ. Sofia V. 34. / 1938, *Mesostomum ehrenbergi*, Kepner, Ferguson and Stirewalt in: Zool. Anz., v. 121, 11 / 12, p. 307. / 1938, *Mesostoma ehrenbergii*, Ruebush in: Zool. Anz., v. 122, 11 / 12. / 1939, *Mesostoma ehrenbergii*, Ruebush in: Zool. Anz., v. 126, 3 / 4 / 1939, *Mesostoma ehrenbergii*, Husted, Ferguson, and Stirewalt in: Amer. Nat., v. LXXIII, pp. 180–185. / 1939, *Mesostoma ehrenbergii*, Hyman in: Amer. Midland Naturalist, v. 21, iii, p. 646, 50. / 1939, *Mesostoma ehrenbergii*, Hyman in: Amer. Midland Naturalist, v. 22, iii, p. 633. / 1940, *Mesostoma ehrenbergii* (Focke), Husted and Ruebush in: Jour. Morph., v. 67, no. 3, p. 387–410, f. 3–15.

Body very flattened (Fig. 12), about one third as wide as long, widest slightly behind the middle, the anterior end gradually narrowed and broadly pointed, the posterior end less gradually but more sharply pointed; body highly transparent, gradually assuming a brownish yellow mesenchyme pigment with advancing age especially in the region of the uteri and other sex organs and just under the body muscle layer; cilia of the anterior end 8 μ to 4 μ long, the cilia of the ventral side better developed than those of the back; rhabdites rod-form rounded at both ends, 3–4 μ long, present in all the epithelial cells, rhammites up to 60 μ long, slightly swollen at the free end, the swelling filled by an often granular material distinguishable from the cortex, the rhammites sparingly present over the whole body and abundantly in the anterior rodways; slime glands located in a strip along the whole ventral surface and especially at the ends; the slime cells at the posterior end pear-shaped, up to 64 μ long and connected to the body surface by ducts of similar length; eyes irregularly three-sided, placed equidistant between the mouth and the anterior end; sensory areas ciliated and specially in-

nervated, located on the anterior dorsal surface; excretory system typical; pharynx a little anterior to the body middle, leading by a typical oesophagus to the rod-shaped enteron; the latter about as wide as the pharynx, its anterior part extending almost to the brain, its posterior part ending some distance anterior to the posterior end of the body, but still nearly twice as long as the anterior part; gonopore posterior to the mouth and removed from it by a distance just greater than the diameter of the pharynx; testes lateral to the vitellaria and occupying roughly the middle third of the body length, each testis slightly irregular on the median side but deeply incised and follicular on the lateral aspect; vasa deferentia arising from the median surface



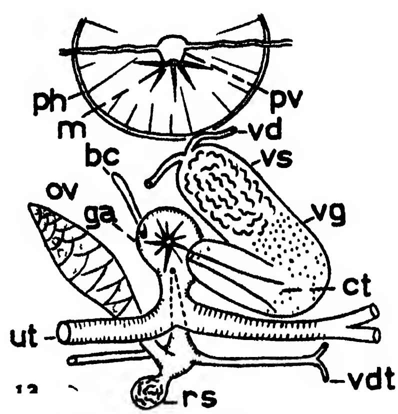


FIGURE 12. Diagrammatic left lateral optical section of sex apparatus of *Mesostoma ehrenbergii* (Focke). × 85. After Luther 1904.

FIGURE 13. Diagrammatic dorsal optical section of sex apparatus of *Mesostoma ehrenbergii* var. *wardi* Ruebush. × ? After Ruebush 1940.

of the testes and passing dorsally above the vitellaria to enter separately but close together into the vesicula seminalis; copulatory organ of retort-form with both ends directed posteriorly; ductus ejaculatorius a narrow tube, but with a characteristic diverticulum, lacking cuticle; the penis papilla extending somewhat into the atrium; on the anterior or anterio-lateral wall; sperm long and thread-like, provided with two flagella; female system typical; bursa an irregularly folded sac, the stalk especially provided with strong ring muscles, the bulb not strongly muscled; receptaculum seminis a spherical distension of the germ duct; vitellaria follicular, extending beside the enteron for nearly the length of the latter; uteri ⊢-shaped, opening, from the sides of the atrium, extending between the vitellaria and the testes and about the length

of the former or, during the production of summer eggs, even longer than the enteron; winter and summer eggs seldom formed in an animal at the same time; summer eggs spherical, 60–80 μ in diameter, thin-shelled, up to as many as 50 per animal; winter eggs lens-form when fully developed, dark brown, thick-shelled, 0.45–0.5 mm. in diameter, up to 31 per animal; chromosome number: N = 5, 2 N = 10; body length up to 15 mm., width 4 mm.; habitat: all Europe, including England, Sweden, Denmark, Holland, France, Switzerland, Austria, Hungary, and Russia; in Asia in Province of Tomsk; and perhaps in Island of Trinidad.

Mesostoma ehrenbergii wardii Ruebush 1940. / 1896, *M. Wardii* Woodworth in: Bull. Mich. Fish Comm., no. 6, p. 95. / 1896, *M. w.*, Woodworth in: Bull. Mus. Comp. Zool. at Harvard, v. 29, p. 241, f. 2. / 1897, *Mesostoma ehrenbergii*, Woodworth in: Bull. Mus. Comp. Zool. at Harvard Coll., v. 31, p. 1-16. / 1918, *M. e.*, Stringer in: Ward and Whipple, Freshwater Biology, p. 352, f. 625. / 1918, *M. e.*, Higley in: Illinois Biol. Monogr., v. 4, no. 3, p. 73. / 1938, *Mesostomum ehrenbergi*, Kepner, Ferguson, and Stirewalt in: Zool. Anz., v. 121, p. 307, 312. / 1939, *Mesostoma ehrenbergii*, Husted, Ferguson, and Stirewalt in: Amer. Nat., v. 73, p. 180–185, f. 1, 2. / 1939, *M. e.*, Hyman in: Amer. Midland Nat., v. 21, no. 3, p. 646. / 1939 b, *M. e.* (probably not equivalent to *M. wardii*), Hyman in: Amer. Midland Nat., v. 22, p. 633. / 1940, *M. e. wardii*, Ruebush in: Science, v. 91, p. 531–532, f. 1.

Body similar in form (Fig. 13) and transparency to *Mesostoma ehrenbergii ehrenbergii* and differing, in so far as is now known, only in the following characteristics: body cilia about 12.5 μ long; occasional bundles of sensory hairs about 35 μ long; male copulatory organ entering postero-lateral wall of genital atrium; ductus ejaculatorius short and without a diverticulum; false vesicula seminalis present or absent*; sperm cell about 1 μ thick and as much as 400 μ long, with two flagella about 53 μ long near one end; bursa copulatrix with strong muscles in the bulb as well as in the stem, the bulb compressed and not greatly in evidence; receptaculum seminis a spherical vesicle separated from the germ duct by a narrow opening; chromosome number: N = 4, 2N = 8; length up to 7 mm.; habitat: Illinois, Nebraska, Kansas, Michigan, New York, Ohio.

The difference in the chromosomes is the most striking and the most thoroughly studied. It may be that some of the habitats reported are

* Original observation.

incorrect, some other species having been mistaken by early workers for the present variety.

M. lingua (Abildgaard) O. Schmidt 1848. / 1789, *Planaria lingua*, Abildgaard in: O. F. Müller, Zool. Dan., ed. 3, v. 3, p. 40, t. 105, f. 7. / 1836, *P. ehrenbergii* (part), W. Focke in Ann. Wien. Mus., v. 1, ii, p. 202, t. 17, f. 13, 14. Wass., p. 40, t. 2, f. 6, 6c. / 1858, *Mesostoma cyathus*, O. Schmidt in: Denk. Ak. Wien, v. 15, p. 29, t. 2, f. 6, 7 (copulation organs). / 1862 *Turbella lingua* and *T. c.*, Diesing in: SB. Ak. Wien, v. 45, i, p. 220, 221. / *Mesostoma lingua*, F. A. Forel in: Bull Soc. vaud. Sci. Nat. Lausanne, v. 16, p. 313–327. / 1882, *M. l.* and *M. c.*, L. Graff in: Monogr. Turbell., v. 1, p. 288, t. 6, f. 1–4a, p. 289 (anatomy). / 1884, *M. l.*, Du Plessis in: Arch. Zool. exper., ser. 2, v. 2, p. 53. / 1885, *M. l.*, M. Braun in: Arch Dorpat. Ges., ser. v, 10, p. 157. / 1886, *M. l.*, Hallez in: CR. Ac. Sci., v. 102, p. 684. / 1886, *M. l.*, C. Vogt (and Yung) in: Lehrbuch vergl. Anat., v. 1, p. 281. / 1889, *M. l.* var. *cyathus*, Sekera in: SB. Bohm, Ges., 1888, p. 328. / 1894, *M. l.*, Hallez in: Cat. Turbell., ed. 2, p. 71. / 1894, *M. l.*, Fuhrmann in: Rev. Suissse Zool., v. 2, p. 238. / 1897, *M. l.*, C. A. Pugnat in: Rev. savoisienne. Annecy. / 1902, *M. l.* and *M. cyathus*, Dorner in: Schr. Ges., Konigsb., v. 43, p. 16, t. 1, f. 2. / 1903, *Mesostomum lingua*, Bresslau in: Verh. D. zool. Ges., v. 13, p. 126, f. 2, C (eggs). / 1904, *M. l.*, Bresslau in: Z. wiss. Zool., v. 76, p. 278, t. 19 (development). / 1904, *M. l.*, Markow in: Trudui Kharkov. Univ., v. 39, p. 34, t. 1, f. 13. / 1904, *M. l.*, Luther in: Z. wiss. Zool., v. 77, p. 222, t. 1, f. 15; t. 2, f. 8–10; t. 3, f. 5, 6, 8, 15, 24, 28; t. 5, f. 12–17, 33, 36; t. 6, f. 1, 2, 14, 15; textf. 2, 5, 9g, 11. / 1905, *M. sigmoideum*, Plotnikow in: Zool. Jahrb. Syst., v. 21, p. 481, t. 25, f. 1. 10. / 1906, *M. lingua*, Brinkmann in: Vid. Meddel., v. 58, p. 93, t. 4. f. 1–4. / 1907, *M. l.*, Hofsten in: Z. wiss. Zool., v. 85, p. 456, t. 23, f, 22, 23. / 1909, *M. l.*, L. Graff in: Brauer, Süssw., v. 19, p. 120, f. 133 g. / 1911, *M. l.*, Hofsten in: Zool. Bidr. Uppsala, v. 1, p. 73. / 1913, *M. l.*, L. Graff in Das Tierreich, v. 35, p. 268–271, f. 239, 240. / 1926, *M. l.*, N. Nassonov in: Bull. Akademiia Sci. URSS. / 1936, *M. l.*, Southern in: Proc. Roy. Irish Acad., v. XLIII, sec. B, no. 5, p. 56–57. / 1938, *M. l.*, Kepner, Ferguson, and Stirewalt in: Zool. Anz., v. 121, 11/12, p. 312. / 1939, *M. l.*, Ruebush in: Zool. Anz., v. 122, 11/12, p. 57, 63, 65. / 1939, *M. l.*, Husted, Ferguson, and Stirewalt in: Amer. Nat., v. 73, p. 184.

Body lancet-shaped (Fig. 14), anteriorly rounded and posteriorly stumped; with paired latero-anterior sensory areas; dirty gold color resulting from parenchymal pigment; rhabdites (4–8 μ) over the body

surface; rhammites (25–35 μ or even 51 μ) in anterior tracts as well as in the body generally; eyes close together, often anastomosing; excretory beaker and protonephridia regular; gonopore posterior to mouth; testes compact, with small posterior and large anterior portion, each portion giving off a vas efferentium which unites with the other of the same side to form the vas deferens of that side, the anterior portions of the testes anastomosing; sperm (280 μ long), with two setae; ductus seminalis rather long; penis simple with uncuticularized ductus ejaculatorius; penis papilla opening into atrium copulatorium, the left (sic) of a pair of diverticula of the undivided genital atrium; other diverticulum receiving all other sex organs except the penis; female genital tract regular; vitellaria ventral, follicular, and branched; uteri ⊢-shaped

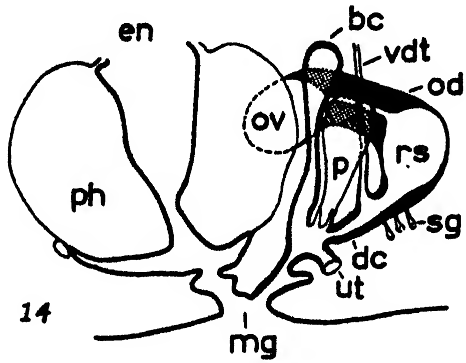


FIGURE 14. Diagrammatic left lateral optical section of sex apparatus of *Mesostoma lingua* (Abildgaard). × 135. After Luther 1904.

with a common opening into the genital atrium; bursa copulatrix pyriform with a narrow, muscular stalk; body length up to 9 mm.; habitat: fresh and brackish water of Sweden, Denmark, France, Germany, Switzerland, Austria, Russia, and Asia.

Graff (1913) rejects two varieties proposed by Hofsten (1907) but tacitly accepts the three varieties proposed by Brinkmann (1906) based chiefly on pigment, size, color, habitat, and egg production. These chiefly physiological differences might, it seems, form the basis for varietal differences. However, the authors feel that the three varieties of *Mesostoma lingua* (*M. l.* forma *typica*, *M. l.* var. *cyathus*, and *M. l. lacustris*) should be viewed with caution until it is shown that the eggs of one variety when placed in the habitat of another variety do not assume on maturity the form of the second variety.

M. macropenis Hyman 1939, *M. m.*, Hyman in: Amer. Midland Nat., v. 21, p. 646–650.

Body short (Fig. 15) fusiform, colorless except for mid-dorsal dark stripe; rhabdite tracts not noticeable; epidermis apparently syncytial, packed with small rhabdites and bearing a few rhammites; eyes evident only in living specimens; excretory system undescribed; gonopore slightly behind mouth; dorso-lateral testes, elongate, lobulate, without anastomosis; well developed ductus seminalis opening into a vesicula seminalis set off from the vesicula granulorum by a constriction and so

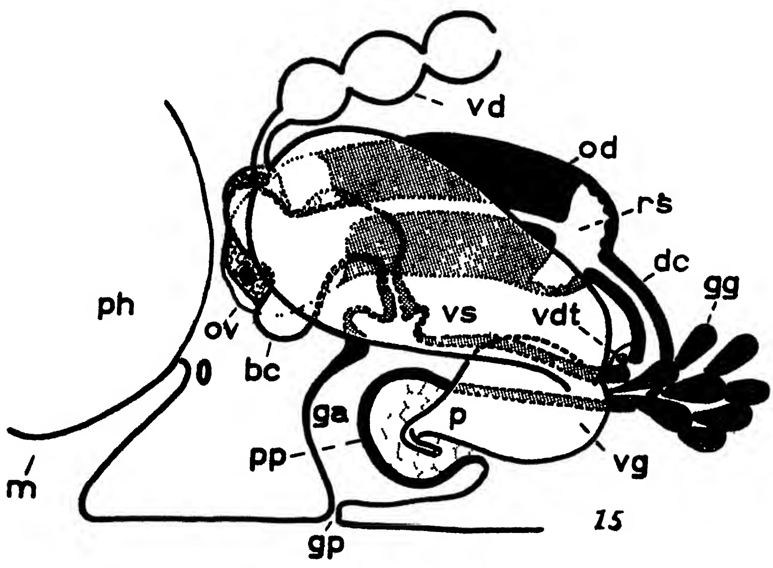


FIGURE 15. Diagrammatic left lateral optical section of sex apparatus of *Mesostoma macropenis* Hyman. × ? After Hyman 1939.

placed as to lie parallel to the latter; vesicula granulorum composed of a series of elongate chambers surrounding the central sperm duct and receiving proximally the long necks of the eosinophilic granule secreting glands; large, beak-like penis papilla continuous with the vesicula granulorum and bulging into the atrium, the uncuticularized ductus ejaculatorius asymmetrically placed; bursa copulatrix an irregular sac opening into the dorsal wall of the common genital atrium by a narrow muscular stalk; female system regular; vitellaria follicular; uteri ⊢-shaped; chromosomes unknown; body length 1.5 mm. or more; habitat: Douglas Lake, Michigan, U. S. A.

M. macroprostatum Hyman 1939, *M. m.*, in: Amer. Midland Nat., v. 22, iii, p. 629–636.

Body elongate (Fig. 16), dark brown, opaque, anteriorly narrowed, posteriorly rounded; pigmentation located not only in the parenchyma; but also in the cellular epithelium where it is concentrated ventrally; rhabdite tracts wanting; eyes elongate, dark; excretory opening typical; gonopore separate from mouth; testes undescribed;* vesicula seminalis small, rounded, set off by a constriction from the large, spindle-shaped vesicula granulorum which receives ventrally and proximally the eosinophilous secretion of the granule glands; penis papilla large, muscular, lacking a cuticular ductus ejaculatorius, cut off proximally from the vesicula granulorum by a valve, and extending distally into the male genital canal; bursa copulatrix present; female system regular,

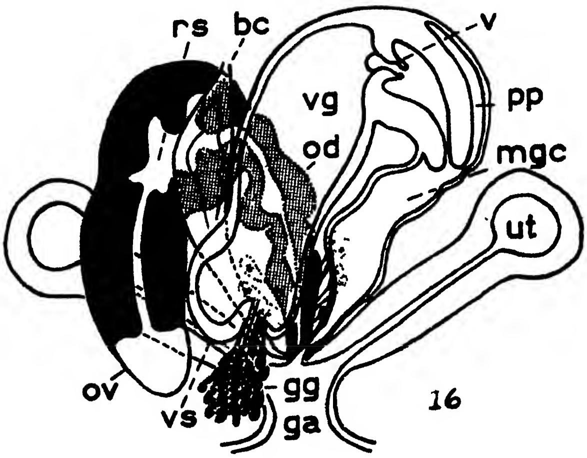


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FIGURE 16. Diagrammatic anterior optical section of sex apparatus of *Mesostoma macroprostratum* Hyman. × ? After Hyman 1939.

rather muscular; vitellaria follicular, lateral; receptaculum seminis thick-walled; paired uteri extending posteriorly and laterally; chromosomes unknown; body length 2.0-2.5 mm.; habitat: temporary pond, elevation 9700 feet, Medicine Bow Mts., Wyoming, U. S. A.

M. mutabile Böhmig 1902, *M. m.*, Böhmig in: Ergeb. Hamb. Magalh.-Sammelr., v. 3, Turbell., p. 4, pl. 1, f. 1–5. / 1904, *M. m.*, Luther in: Z. wiss. Zool., v. 77, p. 235, pl. 1, f. 25, 27, 36; pl. 2, f. 1, 2; pl. 5, f.

* Hyman has commented on the difficulty of assigning a member of the Typhloplanidae to its proper genus without a knowledge of the testes. The authors feel that Hyman's disposal of the animal under discussion is justified, since the animal could not be made to fit any other genus even if the testes were assumed to be ventral and since it does fit the genus *Mesostoma* if the testes are assumed to be dorsal to the vitellaria.

18–28, 37, 39. / 1938, *M. m.*, Kepner, Ferguson and Stirewalt in: Zool. Anz., v. 121, p. 313. / 1939, *M. m.*, Ruebush in: Zool. Anz., v. 126, p. 64.

Form of the body similar (Fig. 17) to that of *M. craci* with four more or less extruded wing-like flaps, the cross-section quadrangular or nearly round, the anterior end Russel-like; body white with net-like pigment in the mesenchyme ventrally and in the region of the sex organs and pharynx; rhabdites spindle-shaped, 10–18 μ long and 2 μ thick, broadly pointed at the ends, abundant over all the body except the anterior end; long, thin, serpentine rhammites present all over the body but especially in the anterior rodways that open ventrally just behind the anterior tip of the body; cyanophylic glands also present, the ducts

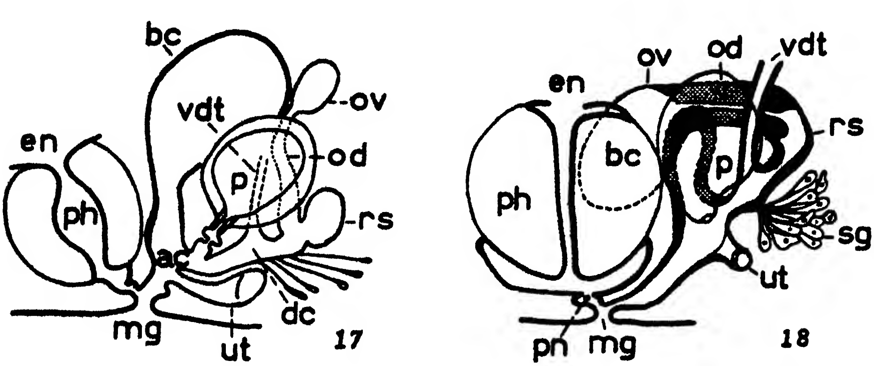


FIGURE 17. Diagrammatic lateral optical section of sex apparatus of *Mesostoma mutabile* Bohmig. × ? After Bohmig 1902.

FIGURE 18. Diagrammatic left lateral optical section of sex apparatus of *Mesostoma productum* (O. Schmidt). × 235. After Luther 1904.

opening ventrally between the brain and the anterior end; eyes somewhat farther apart than in *M. craci.* Excretory system typical; mouth and gonopore combined; testes lateral, above the enteron, extending from the middle of the body to the posterior tip, anastomosed at the posterior end and sometimes at the anterior part or in the middle; vasa deferentia uniting shortly before entering the vertex of the vesicula seminalis; ducts of two kinds of granule glands entering the penis bulbus around the entrance of the vas deferens; bulbus of the penis spherical, distinctly smaller than the bursa; cuticular ductus ejaculatorius about 166 μ long opening into the atrium copulatorium cut off from the rest of the atrium by a sphincter; bursa with a large oval enlargement and a muscular stem; female system regular; receptaculum seminis a distension of

the germ duct; vitellaria papillose, extending from the brain to somewhat over the anterior ends of the testes; uteri simple; winter eggs from 1-8 per animal, brownish yellow in color, biconcave, .4-.5 mm. in diameter; length of the fixed animal 4 mm., breadth 1-2 mm.; habitat: fresh water pools of Uschuaia south Feuerland.

M. nigrorostrum M. Braun 1885, *M. n.*, M. Braun in: Arch. Dorpat. Ges., ser. 2, v. 10, p. 179, pl. 1, f. 3; pl. 2, f. 14, 15. / 1904, *M. n.*, Luther in: Z. wiss. Zool., v. 77, p. 249. / 1906, *M. n.*, Brinkmann in: Vid. Meddel., v. 58, p. 97, pl. 4, f. 5-14; textf. 9, 10. / 1909, *M. n.*, L. Graff in: Brauer, Sussw., v. 19, p. 126, f. 234. / 1938, *M. n.*, Hyman in: Amer. Mus. Novitates, no. 1005, p. 4. / 1938, *M. n.*, Kepner, Ferguson and Stirewalt in: Zool. Anz., v. 121, p. 312. / 1939, *M. n.*, Ruebush in: Zool. Anz., vol. 126, p. 64.

Body elongate, broadest anteriorly, gradually narrowed to the usually rounded sometimes pointed posterior end, anterior end rounded and with a Russel-like tip whose cross-section is +-shaped, the keels of the Russel highest in the region of the eyes and diminished posteriorly where the cross-section is oval or circular; color greyish brown, the pigment aggregated into spherical masses in the mesenchyme anteriorly and into net-like configurations posteriorly, the color sometimes concentrated in the region of the brain, pharynx, and sex organs and usually greatest on the dorsal side, rhabdites crowded in the outer third of the epithelial cells; rhammites present in the anterior rodways opening at the Russel-like tip; eyes black, placed rather far forward, equidistant from one another and the sides of the body, and provided with lenses; excretory system typical; mouth anterior to the middle of the body, opening into a common depression with the gonopore; testes similar in form and extent to those of *M. craci:* vasa deferentia opening into the vertex of the copulatory organ; general form of the penis bulbus similar to that of *M. rhynchotum;* ductus ejaculatorius lined by a thick-walled cuticular tube little widened at the basal end and bearing at the outer edge a row of very fine points, the cross-section of the cuticle showing two well-defined keels on the outside; bursa thin-walled, spherical; female system regular; receptaculum seminis a distension of the germ duct; vitellaria follicular, extending as far as the enteron and in contact with it except in the region of the pharynx and sex organs; uteri simple extending posteriorly; eggs thick-shelled, concavo-convex, reddish brown; summer eggs not known; length up to 6 mm.; habitat: moor pools in Dorpat and in Denmark; very sluggish, never known to swim.

M. platycephalum M. Braun 1885, *M. p.*, M. Braun in: Arch. Dorpat.

Ges., ser. 2, v. 10, p. 161, pl. 2, f. 9, 10. / 1904, *M. p.*, Luther in: Z. wiss. Zool., v. 77, p. 249. / 1909, *M. p.*, L. Graff in: Brauer, Süssw., v. 19, p. 126, f. 233. / 1938, *M. p.*, Kepner, Ferguson and Stirewalt in: Zool. Anz., v. 121, p. 312.

Body slender, provided with dorsal and ventral median keels, the posterior end pointed, the anterior end rounded and dorso-ventrally flattened; mesenchyme pigment red-brown; distributed over the whole body; rhammites long and thick, occurring in the rodways; brain at the end of the first body fifth and just in front of the enteron; eyes small, black, provided with lenses, and placed so close together that they are almost connected by a bridge; excretory system typical; testes elongate, band-form, divided in older individuals into several pieces; vasa deferentia opening one behind the other on the dorsal surface of the penis bulb; common genital atrium lined by a cuticular membrane; bursa small, spherical, not sharply set off from its stem; female system regular; receptaculum seminis a spherical distension of the germ duct; vitellaria follicular, ventral, extending the entire length of the enteron; uteri simple, extending posteriorly; eggs concavo-convex, reddish brown in color; length up to 4.5 mm.; habitat: fresh water pools, Dorpat, Russia.

M. productum (O. Schmidt.) 1774, *Fasciola grossa*, O. F. Müller, Verm. terr. fluv., v. 1–II, p. 67. / 1776, *Planaria g.*, O. F. Müller, Zool. Dan. Prodr., p. 222. / 1779, *P. g.*, Abildgaard in: O. F. Müller, Zool. Dan., ed. 3, v. 3, p. 40, pl. 105, f. 5. / ? 1826, *P. grisescens*, O. Fabricius in: Danske Selsk. Afh., v. 2, p. 19, pl. IE. / ? 1828, *Derostoma grossum*, Ant. Dugés in: Ann. Sci. nat., v. 15, p. 142, pl. 4, f. 6 / ? 1830, *D. g.*, Ant. Dugés in: Ann. Sci. nat., v. 21, p. 78, pl. 2, f. 15. / 1837, *Mesostoma grossum*, Ehrenberg in: Abh. Ak. Berlin, p. 244. / 1848, *Schizostomum productum*, O. Schmidt, Rhabd. Strudelw. süss. Wass., p. 59, pl. 6, f. 16, 16a. / 1854, *Mesostomum p.*, R. Leuckart in: Arch. Naturg., v. 20–II, p. 349. / 1858, *M. fallax*, O. Schmidt in: Denk. Ak. Wien, v. 15, p. 34, pl. 3, f. 6, 7. / 1862, *Turbella producta* + *T. f.*, Diesing in: SB. Ak. Wien, v. 45–I, p. 221. / 1882, *Mesostomum productum*, L. Graff, Monogr. Turbell., v. 1, p. 287. / 1885, *M. p.*, M. Braun in: Arch. Dorpat. Ges., ser. 2, v. 10, p. 156, pl. 2, f. 20. / ? 1890, *Mesostomum grossum*, L. Vaillant, Hist. nat. Annel., v. 3–II, p. 635, 642 pl., 28, f. 5. / 1894, *Mesostoma productum*, Hallez, Cat. Turbell., ed. 2, p. 70. / 1894, *M. p.*, Sekera in: Zool. Anz., v. 28, p. 236. / 1899, *Mesostomum p.*, Bresslau in: Zool. Anz., v. 22, p. 422, f. 4c, 4d. / 1902, *Mesostoma p.*, Dorner in: Schr. Ges. Konigsb., v. 43, p. 16. / 1903, *Mesostomum p.*, Bresslau in: Verh. D. zool. Ges., v. 13, p. 126. / 1904, *M. p.*, Luther in: Z. wiss.

Zool., v. 77, p. 218, pl. 1, f. 26; pl. 2, f. 3; pl. 5, f. 31, 41; pl. 7, f. 1; textf. 6, 10, 16. / 1904, *M. p.*, Markow in: Trudui Kharkov. Univ., v. 39, p. 36. / 1909, *M. p.*, L. Graff in: Brauer, Süssw., v. 19, p. 119. / 1938, *M. p.*, Kepner, Ferguson and Stirewalt in: Zool. Anz., v. 121, p. 313. / 1939, *M. p.*, Ruebush in: Zool. Anz., v. 126, p. 55, 57.

Body elongate (Fig. 18), the ends broadly pointed, the anterior end more acute than the posterior; epithelium clear but the body colored by oil drops and black-brown pigment granules, the latter organized into large branched clumps more abundant ventral to the enteron than dorsally; cilia of the dorsal side a half longer than those of the ventral side; rhabdites 3–4 μ long and as much as 0.5 μ thick, filling the peripheral part of the epithelial cells; rhammites rounded at one end and pointed at the other, 30 μ long and 1 μ thick in the anterior rodways, only about 10 μ long over the rest of the body; eyes composed of finely granular dark brown pigment cups placed close together and often connected by a bridge at the end of the first body sixth; excretory system regular; pharynx located at the margin of the first and second body thirds and opening together with the gonopore; dorsal lying testes weakly developed, sometimes according to Luther with only a single testis developed which then lies as an irregularly nodulated band dorsal to and slightly longer than the enteron;* vasa deferentia opening on the side of the blind end of the penis bulb that receives at the vertex the granule glands; copulatory organ thin-walled, retort-form, covered by two layers of spiral muscle; broad ductus ejaculatorius funnel-form at the proximal end and about 45 μ in length, provided with a cuticular lining; bursa thick-walled, provided with strong ring muscles; female system regular; receptaculum seminis usually a mere distension of the germ duct, sometimes an outpocketing from the duct; vitellaria strongly developed composed of an anterior and a posterior mass of follicles on each side, the follicles of each mass arranged about a central yolk duct, the two masses of each side separated by a length of yolk duct lacking follicles; uteri simple, extending posteriorly; summer eggs as many as 23 in one animal and often present at the same time with winter eggs; egg production essentially as in *M. ehrenbergii*; length 4.8 mm.; habitat: fresh water pools and lakes of Europe including Denmark, France, Germany, Switzerland (as much as 60 m. deep in Genfer Lake), Austria, Hungary, Russia (from Solowetzk to Odessa), and Asia (Tomsk).

* It would seem that this single testis might well be a fusion product as in *M. virginiana*.

M. punctatum M. Braun 1885, *M. p.*, M. Braun in: Arch. Dorpat. Ges., ser. 2, v. 10, p. 175, pl. 1, f. 2; pl. 2, f. 16–19. / 1904, *M. p.*, Luther in: Z. wiss. Zool., v. 77, p. 244. / 1904; *M. p.*, Markow in: Trudui Kharkov. Univ., v. 39, p. 32. / 1909, *M. p.*, L. Graff in: Brauer, Sussw., v. 19, p. 124. / 1938, *M. p.*, Kepner, Ferguson and Stirewalt in: Zool. Anz., v. 121, p. 312. / 1939, *M. p.*, Ruebush in: Zool. Anz., v. 126, p. 64, 65.

Body narrowed anteriorly and bluntly pointed, little narrowed posteriorly and rounded at the end, body plump, the cross-section of contracted or fixed animals quadrangular; ground color a bright greyish yellow with spots of brown or red-brown resulting from pigment cells in the mesenchyme; rhammites present in the anterior rodways and more sparingly on the ventral surface; eyes composed of lense-provided pigment cups, dark brown in reflected light, black in transmitted light, placed at the end of the first body fifth and about one half as far apart as from the sides of the body; excretory system typical; pharynx lying in the middle or somewhat behind the middle of the body; mouth and gonopore not combined; testes elongate, ribbon-shaped, dorsal to but not as long as the enteron; copulatory organ pear-shaped, provided with thick muscular walls; penis short and conical, covered both inside and out with a cuticular membrane; bursa muscular, spherical or oval, and provided with a short stalk, the whole organ covered by a glistening membrane; female system regular; receptaculum a spherical diverticulum of the germ duct; vitellaria elongate, follicular or papillose; uteri simple, extending posteriorly; eggs 3–4 per animal, reddish brown in color, the shells concavo-convex, and 0.4 mm. across; length up to 5 mm.; habitat: fresh water of Russia (Livland, Charkow).

M. rhynchotum Braun 1885, *M. r.*, M. Braun in: Arch. Dorpat. Ges., ser. 2, v. 10, p. 173, t. 1, f. 6, t. 3, f. 7–10. / 1904, *M. r.*, Luther in: Z. wiss. Zool., v. 77, p. 248. / 1906, *M. rhynchotum*, Brinkhmann in: Vid. Meddel., v. 58, p. 102, t. 4, f. 15, 16; tf. 11, 12 (Anat). / 1909, *M. rhynchotum*, L. Graff in: Brauer. Süssw., v. 19, p. 125, f. 232. / 1913, *M. r.*, L. Graff in: Das Tierreich, v. 35, p. 283, f. 247. / 1938, *M. r.*, Hyman in: Amer. Museum Novitates, No. 1005, p. 4. / 1939, *M. r.*, Ruebush in: Zool. Anz., v. 126, p. 63, 64.

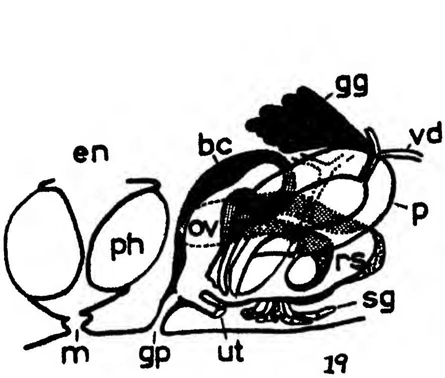
Body plump, anteriorly narrowed with small, protrusible, almost Russel-like projection, posteriorly broadly rounded with small projecting tail; pigment greyish brown, parenchymal, enteron darker; eyes close together, black, often with a tinge of cherry red; excretory system undescribed; gonopore immediately posterior to mouth; testes cylindrical, compact, dorsal, without anastomosis; ductus seminalis short;

penis bulb thickly muscular, pyriform, containing both vesicula seminalis and vesicula granulorum; ductus ejaculatorius cuticular, widened at the base into a sort of funnel; female reproductive system regular; vitellaria follicular, lateral; bursa copulatrix with cuticular lining, the wall of strong circular muscles; uteri posterior; chromosomes unknown; body length up to 3 mm.; habitat: fresh water Livlands and Denmark.

M. tetragonum (Müller) 1774, *Fasciola tetragona*, O. F. Müller, Verm. terr. fluv., v. 1–II, p. 69. / 1776, *Planaria t.*, O. F. Müller in: Zool. Dan. Prodr., p. 223. / 1789, *P. t.* (part.), Abildgaard in: O. F. Müller, Zool. Dan., ed. 3, v. 3, p. 42, pl. 106, f. 1–4. / 1836, *P. ehrenbergii* (part.), W. Focke in: Ann. Wien. Mus., v. 1–II, p. 202, pl. 17, f. 9, 10. / 1848, *Mesostomum tetragonum*, O. Schmidt, Rhabd. Strudelw. süss. Wass., p. 44, pl. 3, f. 8, 8c. / 1851, *M. t.*, M. Schultze, Beitr. Turbell., p. 9–32, pl. 1, f. 4–6, 18–20, 24, 25, 29, 31–34. / 1862, *Turbella tetragona* (part.), Diesing in: SB. Ak. Wien, v. 45–I, p. 221. / 1879, *Mesostomum t.*, Hallez in: Trav. Wimereux, v. 2, p. 44, 55, pl. 1, f. 3; pl. 6, f. 7, 11; pl. 10, f. 20. / 1885, *Mesostoma tetragonum*, M. Braun in: Arch. Dorpat. Ges., ser. 2, v. 10, p. 168, pl. 1, f. 1; pl. 4, f. 3. / 1894 *M. t.*, Hallez, Cat. Turbell., ed. 2, p. 73. / 1904, *M. t.*, Luther in: Z. wiss. Zool., v. 77, p. 244, pl. 2, f. 15; pl. 4, f. 18, 20, 22; pl. 5, f. 32, 38; pl. 7, f. 2; textf. 7, 9 E. / 1909, *M. t.*, L. Graff in: Brauer, Süssw., v. 19, p. 124, f. 133 E, 230, 231. / 1939, *M. t.*, Ruebush in: Zool. Anz., v. 126, p. 64.

Body (Fig. 19) a third or more as wide as long, four cornered in cross-section and provided with four lamellae of which the ventral pair is always somewhat broader; color reddish yellow or almost transparent; rhabdites about 2 μ long, numerous in the peripheral part of the epithelial cells; rhammites 50 μ long and 4 μ thick, long, coiled, and somewhat thickened at one end, abundant in the anterior rodways and to a lesser extent at the angles or the lamellae; mucous or spinning glands numerous on the ventral surface; eyes black, provided with lenses, placed close together over the brain and shortly in front of the enteron; excretory system regular; pharynx proportionately small; placed somewhat behind the middle of the body; oesophagus receiving a ring of long-stemmed glands; enteron rod-shaped, extending an equal distance anteriorly and posteriorly from the pharynx; gonopore clearly separated from the mouth; testes dorsal, composed of three pairs of clusters of follicles, one pair placed at the level of the pharynx, one at the middle of the anterior branch of the enteron, and the third at the middle of the posterior branch of the enteron; vasa eferentia from the various clusters uniting to form the paired vasa deferentia; the latter entering the vertex

of the penis bulb between the ducts of the two sorts of granule glands; penis bulbus oval in shape, provided with a strong musculature of four layers, the inner circular layer stronger than the outer longitudinal and two intermediate spiral layers taken together; vesicular seminalis and vesicula granulorum situated beside one another in the bulbus; ductus ejaculatorius lined by cuticle, widened funnel-like at the basal end, the whole about 176 μ long; bursa copulatrix large, provided with a stem and unusually strong ring muscles; female system regular; receptaculum seminis a swelling of the germ duct; vitellaria follicular, the follicles somewhat shorter than those of *M. craci*; uteri ⊢-shaped, containing as



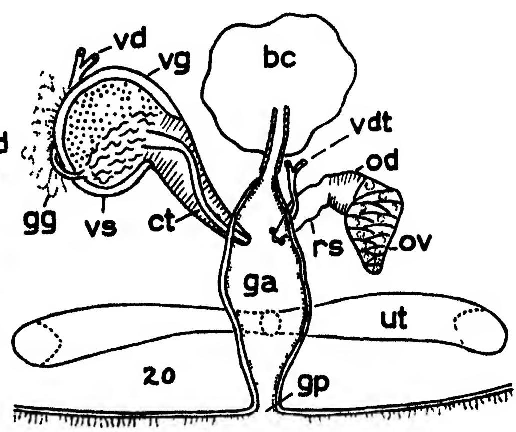


FIGURE 19. Diagrammatic left lateral optical section of sex apparatus of *Mesostoma tetragonum* (Müller). × 62. After Luther 1904.

FIGURE 20. Diagrammatic anterior optical section of sex apparatus of *Mesostoma togarmensis* Ruebush. × 45. After Ruebush 1939.

many as 120 eggs per animal; eggs concavo- or plano-convex, sometimes biconcave; length 10 mm., seldom over 12 mm.; habitat: freshwater of England, Denmark, Holland, France, Germany, Switzerland, Austria, Russia (Dorpat, Saratow).

M. togarmensis Ruebush 1939, *M. t.*, Ruebush in: Zool. Anz., v. 126, 3/4, p. 57–60, 61, 62, 63, 65, 66, f. 4, 5.

Body bluntly rounded anteriorly (Fig. 20), widest in pharyngeal region, tapering to a point posteriorly; pigment dark brown, parenchymal; eyes large; rhabdites present in cellular epithelium and rhammites in anterior tracts; excretory system undescribed; mouth and gonopore combined; testes elongate, anastomosing anteriorly and posteriorly; bulbus of penis with an inner layer of circular muscle; ductus ejacula-

torius an elongate, highly differentiated, curved, cutilarized tube (280 μ); female genital system regular; receptaculum seminis cut off by a sphincter from the undivided genital atrium; vitellaria follicular; paired uteri extending latero-posteriorly from the common uterine pore in the basal part of the atrium; bursa copulatrix a thin-walled muscular bladder with a thin, highly muscular stalk cut off from the atrium by a sphincter; chromosomes: N = 4, 2N = 8; body length up to 3 mm.; habitat: Togarma Tso, Tibet.

Mesostomum virginiana K., F., and S. 1938, *Mesostomum virginianum* Kepner, Ferguson, and Stirewalt in: Zool. Anz., v. 121, 11/12, p. 307–313. / 1939, *Mesostoma virginiana,* Ruebush in: Zool. Anz., v. 126, 3/4, p. 64. / 1939, *M. v.*, Hyman in: Amer. Midland Nat., v. 21, iii, p. 646.

Body oblanceolate (Fig. 6), the smaller end anterior; pliable lateral body flaps present; color chocolate brown; rhabdite tracts open anteriorly by two groups of minute pores; dermal rhabdites (2 μ) closely packed in cellular epidermis; eyes black, crescent-shaped, irregular, often anastomosing; excretory system regular; mouth slightly anterior to mid-body; gonopore separate from mouth; large dorsal testis compound, the anastomosis of the two units almost complete; vasa deferentia short; bulbus of penis containing both the vesicula seminalis and the granulorum; penis papilla containing a short, cuticular ductus ejaculatorius and diminutive blind sac; atrium copulatorium present; ovary small and oval; oviduct thick-walled, receptaculum seminis a muscular dilation of the oviduct; paired uteri extending latero-posteriorly; vitellaria aboreal; bursa copulatrix Florence flask-shaped; common genital atrium divided into superior and inferior genital atria; chromosomes: N = 4, 2N = 8; body length 3 mm.; habitat: high mountain swamps, Green County, Virginia, U. S. A.

LIST OF SPECIES NOT ACCEPTED IN THE GENUS *Mesostoma*

(Although *Mesostoma* is the older and correct spelling of the genus name, the form *Mesostomum* seems to have been used quite as much. In the following list the form used by the author in question is retained.)

Mesostomum agile Levinsen 1879, transferred to *Promesostoma a.* by L. Graff in: Monogr. Turbell., v. 1, p. 274, 1882.

Mesostomum agilis Levinsen 1879, transferred to *Maehrenthalia* by L. Graff in: Z. wiss. Zool., v. 83, p. 97, 1905.

Mesostoma ajpetri Nassonov 1923, relegated to *species dubiae* by Kepner, Ferguson, and Stirewalt in: Zool. Anz., v. 121, 11/12, p. 313, 1938.

Mesostoma andicola Schmarda 1859, relegated to *species dubiae Rhabdocoelorum* by Luther in: Z. wiss. Zool., v. 77, p. 279, 1904.

Mesostoma angulare Higley 1918, relegated to *species dubiae* by Hyman in Amer. Midland Naturalist, v. 22, iii, p. 633, 1939.

Mesostoma antarcticum Dreyer 1918, declared to be incompletely described and almost identical to *M. mutabile* (which see) by Ruebush in: Zool. Anz., v. 126, 3/4, p. 64, 1939.

Mesostoma armatum Fuhrmann 1894, transferred to *Castrada armata* by Luther in: Z. wiss. Zool., v. 77, p. 212, 1904.

Mesostoma aselli Kennel 1898, assigned to *species dubiae* by Luther in: Z. wiss. Zool., v. 77, p. 259, 1904.

Mesostoma auditivum Forell (?) and Du Plessis 1874, transferred several times and finally to *Otomesostoma a.* by Hofsten in: Z. wiss. Zool., v. 85, p. 555, 1907.

Mesostomum bacilliferum Diesing 1862. Poorly and incompletely described.

Mesostoma balatonicum Szigethy 1897, relegated to *species dubiae* by Luther in: Z. wiss. Zool., v. 77, p. 259, 1904.

Mesostomum banaticum Graff 1875. The animal lacks a bursa copulatrix and because of this as well as the anatomy of the vitellaria and testes, it is obviously not a *Mesostoma*. The worm is not sufficiently well described to be assigned to a genus.

Mesostomum bifidum McIntosh 1875, transferred many times and finally assigned to *Astorhynchus bifidus* by Graff in: Das Tierreich, v. 35, p. 177, 1913.

Mesostomum bistrigatum Oersted 1844 (?). Poorly and incompletely described.

Mesostomum chlorosticum O. Schmidt 1857, relegated to *species dubiae Rhabdocoelorum* by L. Graff in: Das Tierreich, v. 35, p. 353, 1913.

Mesostoma climenti Nassonov 1923, relegated to *species dubiae* by Kepner, Ferguson, and Stirewalt in: Zool. Anz., v. 121, 11/12, p. 313, 1938.

Mesostoma coecum Silliman, 1884 & 1885, transferred to *Olisthanella coeca* by Luther in: Z. wiss. Zool., v. 77, p. 148, 1904.

Mesostoma cuenoti Dorner 1900, transferred to *Castrada c.* by Luther in: Z. wiss. Zool., v. 77, p. 186, 1904.

Mesostoma cyathus O. Schmidt 1858, declared identical to *Turbella lingua* (same as *Mesostoma lingua*) by Diesing in: SB. Ak. Wien, v. 45, I, p. 220-221, 1862.

Mesostoma cyathus Dorner 1902, declared identical to *M. chromobractrum* by Luther in: Z. Wiss. Zool., v. 77, p. 227, 1904.

Mesostoma cycloposthe Dorner 1902, declared identical to *M. armatum* (which see) by Luther in: Z. wiss. Zool., v. 77, p. 212, 1904.

Mesostomum echinatum Uljanin 1870, transferred to *Proxenetes echinatus* by L. Graff in: Monogr. Turbell., v. 1, p. 283, 1882; but relegated to *species dubiae* by Graff in: Das Tierreich, v. 35, p. 200, 1913.

Mesostomum ellipticum Uljanin 1870, transferred to *Promesostoma e.* by L. Graff in: Monogr. Turbell., v. 1, p. 273, 1882.

Mesostomum ensifer Uljanin 1870, declared identical to *Promesostoma marmoratum* by L. Graff in: Monogr. Turbell., v. 1, p. 269, 1882.

Mesostoma exiguum Dorner 1902, transferred by Luther to *Olisthanella exigua* in: Z. wiss. Zool., v. 77, p. 148, 1904.

Mesostomum fallax O. Schmidt 1858, declared identical to *Turbella producta* (same as *Mesostoma productum*) by Diesing in: SB. Ak. Wien, v. 45, I, p. 221, 1862.

Mesostoma flavida Graff 1882, transferred to *Castrada flavida* by Luther in: Z. wiss. Zool., v. 77, p. 183, 1904.

Mesostoma fusiforme Duges 1830, relegated to *species dubiae* by Luther in: Z. wiss. Zool., v. 77, p. 259, 1904.

Mesostoma gangetica Dutta 1925, relegated to *species dubiae* by Ruebush in Zool. Anz., v. 126, 3/4, p. 45, 1939.

Mesostoma gonocephalum Silliman 1884, transferred to *Strongylostoma g.* by L. Graff in: Z. wiss. Zool., v. 99, p. 56, 1911.

Mesostoma gracile Schmarda 1859, relegated to *species dubiae* by Luther in: Z. wiss. Zool., v. 77, p. 259, 1904.

Mesostoma graffi Mereschkowsky 1879, transferred to *Promesostoma g.* by L. Graff in: Monogr. Turbell., v. 1, p. 273, 1882.

Mesostoma griseum O. F. Müller 1789, relegated to *species dubiae* by Luther in: Z. wiss. Zool., v. 77, p. 259, 1904.

Mesostoma grossum Ehrenberg 1837, equivalent to *M. productum.*

Mesostomum hallezianum Vejdovsky 1880, transferred several times and finally to *Olisthanella halleziana* by L. Graff in Brauer, Sussw., v. 19, p. 101, 1909.

Mesostomum herclotısanum de Man 1874, declared identical to *Strongylostoma radiatum* by Luther in: Z. wiss. Zool., v. 77, p. 149, 1904 .

Mesostomum hirudo O. Schmidt 1858, transferred several times and finally placed with reservation as *Castrada h.* by Hofsten in: Z. wiss. Zool., v. 85, p. 445, 1907.

Mesostoma hystrix Schmarda 1859, relegated to *species dubiae* by Luther in: Z. wiss. Zool., v. 77, p. 259, 1904.

Mesostoma karrooense Dreyer 1914. The animal is incompletely described, but differs from other *Mesostoma* in lacking a well-defined bursa copulatrix and in the possession of a "vagina" (sic), a specialized portion of the ductus communis. So far as one can tell from the description the vitellaria are dorsal to the testes, a condition which at once removes the animal from the genus *Mesostoma.* Dreyer himself considered his specimens very atypical of the genus.

Mesostoma lacteum Neppi 1904, assigned to *species dubiae Mesostominorum* by Graff in: Das Tierreich, v. 35, p. 292, 1913.

Mesostoma lanceola Braun 1885, transferred to *Castrada l.* by Luther in: Z. wiss. Zool., v. 77, p. 186, 1904.

Mesostomum lapponicum Schmidt 1852. The animal is very poorly and incompletely described, but is obviously not a *Mesostoma.*

Mesostomum lenticulatum O. Schmidt 1852, transferred to *Promesostoma l.* by L. Graff in: Monogr. Turbell., v. 1, p. 274, 1882.

Mesostomum lugundense de Man 1874, placed tentatively with *Olisthanella* by L. Graff in: Das Tierreich, v. 35, p. 212, 1913. But already placed in *species dubiae* by Luther in: Z. wiss. Zool., v. 77, p. 148, 1904.

Mesostoma maculatum Hofsten 1917, recognized by Ruebush, 1939. Description poor.

Mesostomum marmoratum Schultze 1851, transferred to *Promesostoma* by L. Graff in: Monogr. Turbell., v. 1, p. 269, 1882.

Mesostomum marmoratum var. *gronlandica* Levinsen 1880, combined with species, see above.

Mesostomum marmoratum var. *maculata* Jensen 1878, combined with species, see above.

Mesostoma masovicum Dorner 1902, assigned to *species incertae Typhloplaninorum* by L. Graff in Das Tierreich, v. 35, p. 260, 1913.

Mesostoma metopoglea Schmarda 1859 (Graff 1882), relegated to *species dubiae Rhabdocoelorum* by Luther in: Zeit. f. wiss. Zool., v. 77, p. 216, 1904.

Mesostoma michaelseni Weiss 1909. This species is described as having the testes ventral to the vitellaria and therefore can not belong to the genus *Mesostoma*. The species may possibly belong in the sub-family Typhloplaninae.

Mesostoma minimum Fuhrmann 1894, transferred to *Typhloplana minima* by Luther in: Z. wiss. Zool., v. 77, p. 174, 1904.

Mesostomum montanum Graff 1875, declared identical to *Rhynchomesostoma rostratum* by Luther in: Z. wiss. Zool., v. 77, p. 158, 1904.

Mesostoma morgiense Du Plessis 1876, declared identical to *M. auditivum* (which see). For history see L. Graff in: Das Tierreich, v. 1, p. 442, 1913.

Mesostoma murmanicum Nassonov (full description, 1925). Nassonov was himself doubtful whether his specimens belonged to the genus *Mesostoma* and in the light of present knowledge they definitely do not. The position of the testes and some other features suggest strongly the genus *Castrada*.

Mesostomum nassonoffi Graff 1882, first described but not named by Nassonov in: Izv. Obshch. Moscov., v. 23, II, p. 44. Transferred to *Olisthanella n.* by Luther in: Z. wiss. Zool., v. 77, p. 148, 1904.

Mesostoma neapolitanum Graff 1882, transferred to *Paramesostoma n.* by Attems: in: Wiss. Meeresunters., v. 21, p. 223, 231, 1897.

Mesostoma normatum Fuhrmann 1894, same as *M. perspicuum* (which see).

Mesostomum obtusum M. Schultze 1851, transferred several times and finally to *Olisthanella o.* by Luther in: Z. wiss. Zool., v. 77, p. 148, 1904.

Mesostoma oscari Graff in 1903, transferred within the genus and finally to *M. craci* (which see) by L. Graff in: Das Tierreich, v. 35, p. 276, 1913.

Mesostomum ovoideum O. Schmidt, 1852, transferred in part to *Promesostoma ovoideum* by Graff in: Monogr. Turbell., v. 1, p. 272; in part to *P. solea* by L. Graff in: ibid., p. 273, 1882.

Mesostoma pattersoni Silliman 1884, assigned to *species dubiae Typhloplanidarum* by Luther in: Z. wiss. Zool., v. 77, p. 259, 1904.

Mesostomum personatum O. Schmidt 1848, transferred to *Bothriomesostoma p.* by Braun in: Arch. Dorpat. Ges., ser. 2, v. 10, p. 187, 1885.

Mesostoma perspicuum Fuhrmann 1894, transferred to *Castrada perspicua* by Luther in: Z. wiss. Zool., v. 77, p. 183, 1904.

Mesostoma platygastricum Steinbock, recognized by Ruebush 1939. Description poor.

Mesostoma pusillum Schmidt 1848, relegated to *species dubiae* by Luther in: Z. wiss. Zod., v. 77, p. 259, 1904.

Mesostomum radiatum Diesing 1850, transferred several times and finally to *Strongylostoma r.* by Luther in: Z. wiss. Zool., v. 77, p. 149, 1904.

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Mesostoma robertsonii Graff 1882, declared identical to *Tetracelis marmorosa* by Luther in: Z. wiss. Zool., v. 77, p. 166, 1904.

Mesostoma rostratum Ehrenberg, 1836, transferred many times and finally to *Rynchomesostoma r.* by Luther in: Z. wiss. Zool., v. 77, p. 157, 1904.

Mesostomum rostratum Hallez 1879, declared identical to *Strongylostoma radiatum* by Luther in: Z. wiss. Zool., v. 77, p. 149, 1904.

Mesostomum segne Fuhrmann 1894, transferred to *Castrada s.* by Luther in: Z. wiss. Zool., v. 77, p. 177, 1904.

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Mesostoma strigatum O. F. Müller 1773, relegated to *species dubiae* by Luther in Z. wiss. Zool., v. 77, p. 259, 1904.

Mesostomum sulphureum, de Mann 1874, transferred several times and finally to *Castrada intermedia* by Luther in: Z. wiss. Zool., v. 77, p. 209, 1904.

Mesostomum tetragonum (O. Müller) Schmidt, 1848, transferred in part to *M. craci* by L. Graff in: Monogr. Turbell., v. 1, p. 295, p. 298, 1882. It must be noted that the name, *tetragonum*, applies to an accepted species (which see).

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Mesostoma uljanini Sabussow 1900, transferred to *Bothriomesostoma essenii* by Luther in: Z. wiss. Zool., v. 77, p. 249, 1904.

Mesostomum variable Weismann 1864, declared identical to *M. rostratum* (which see); for history see Graff in: Das Tierreich, v. 35, p. 220, 1913.

Mesostoma vedovskyi Jaworowski 1893, declared identical to *M. hallezianum* (which see) by Sekera in: Zool. Anz., v. 27, p. 435, 1904.

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Mesostomum viridatum M. Schultze 1851, transferred in part to *Typhloplana viridata* by Luther in: Z. wiss. Zool., v. 77, p. 173, 1904.

Mesostoma viridis Pereyaslawzewa 1892, *nomen nudum.*

Mesostoma vivaparum Silliman 1884, declared identical to *M. viridatum* (which see) by Woodworth in: Bull. Mus. Harvard, v. 29, p. 241–242, 1901.

Mesostomum wandae O. Schmidt 1858, declared identical to *M. rostratum* Ehrenberg (which see) by Diesing in: SB Ak. Wien, v. 45, I, p. 220–222, 1862.

Mesostomum wandae Nassonov 1877, declared identical to *Strongylostoma radiatum* by Luther in: Z. wiss. Zool., v. 77, p. 149, 1904.

Mesostoma wardii Woodworth 1897, now classified not as a separate species, but as a variety of *M. ehrenbergii* by Ruebush 1940.

Mesostoma yungi Fuhrmann 1900, declared identical to *Tetracelis marmorosa* by Luther in: Z. wiss. Zool., v. 77, p. 166, 1904.

SUMMARY

The authors have essayed to make a careful study of the *Mesostoma* literature in order to evaluate and properly place the singularly few valid species and to bring together a more complete list of *species dubiae.* This latter list has grown inordinately, it seems, because of the improper designation of a large number of animals as mesostomes early in the history of the genus. This has been attended with an unprecedented carelessness in taxonomic differentiation. In order for the studies upon *Mesostoma* to improve, it is of the utmost importance that taxonomic characters be selected which display morphological differences and permanence, and that such flimsy, inconstant characters as "pigment" and "cross-section configuration" be deleted from the list of characters used for the determination of species. The valid species recognized by this study may easily be distinguished by the morphology of the organs composing the hermaphroditic sexual apparatus.

The members of *Mesostoma* have many interesting features which should invite further study of the genus. Especially noteworthy are the chromosomes which are large in size, small in number, and easy to distinguish one from another. It is suggested that the existence of such chromosomes in animals of complex, yet easily observable morphology, is conducive to genetic as well as cytological study. It is further suggested that the size and translucency of some of the species adapts them to convenient physiological study *in vivo.*

COLLEGE OF WILLIAM AND MARY—V. P. I.
NORFOLK DIVISION AND U. S. P. H. S., CRANEY ISLAND.
UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN.

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STUDIES ON THE TURBELLARIAN FAUNA OF THE NORFOLK AREA

VI. Anatomy of *Macrostomum appendiculatum* var. *stirewalti* New Variety

By E. Ruffin Jones, Jr., and Frederick F. Ferguson

Plate 1

The Norfolk region presents an excellent opportunity for the study of marine and freshwater forms, because here may be found one of the most variable ecologic habitats in this country. Thus, it is not surprising that in a few months time we have gathered data upon nearly fifty new Turbellaria. This paper presents the microscopic anatomy of one of these, a new variety of a rhabdocoelid, *Macrostomum appendiculatum* var. *stirewalti.**

Ecology.—This free-living worm inhabits the fresh water lakes of the water supply system of the City of Norfolk (Smith Lake and Little Creek Reservoir) and the series of ponds paralleling Shore Drive near Lynnhaven Inlet, Princess Anne County, Virginia. The animal was first taken in February, 1940, under a two inch layer of ice associated with an abundance of *Ricciocarpus, Sagittaria* and *Spirogyra.* Crustacea and Protozoa were also numerous. Altitude, about 4 feet. Geology, estuarine sand.

*Description.***—Body colorless, dorsoventrally compressed (Fig. 1), anteriorly truncated, posteriorly slightly spatulate, broadest at mid-body level. Length *ca.* 1.5 mm. Epidermis of flat pentagonal cells bearing an even coat of cilia (*ca.* 5 μ). Sensory hairs overall, extremely long (*ca.* 45 μ) single and in groups of two and three. Spines confined to cephalic and caudal extremities. Rhabdoids abundant; rhabdites (*ca.* 13 μ) in groups of 7 to 9 overall except sub-anteriorly, sparse and single there (Fig. 4), *Stabchen* numerous, ventro-radially dispersed at female

* Named for Dr. M. A. Stirewalt in recognition of profound studies upon American Turbellaria. A research grant from the Virginia Academy facilitated this study.

** Measurements given are average figures taken from the study of many specimens.

gonopore (Fig. 9), *Rhammiten* abundant, anteriorly strongly developed above and below "brain" commissure. "Brain" of paired cerebral ganglia mesially united by restricted commissure, paired nerves course latero-longitudinally. Eyes (*ca.* 20 μ), black and paired (Fig. 3) disposed at postero-dorsal cerebral surfaces. Mouth limited by ciliated longitudinal lips, located antero-ventrally in mid-line. *Pharynx simplex* antero-ventral, abundantly supplied with latero-posteriorly directed system of slender pyriform pharyngeal glands (Fig. 2) bearing granules and *Rhammiten.* Enteron colorific, sac-like and extensive with ciliated endodermal epithelium. Excretory system of paired and separate lateral protonephridia each opening externally (Fig. 4) just meso-dorsal to anterior tip of the testes, terminal flame cells (Fig. 5) numerous. Testes obovate (Fig. 6), smooth-walled, located latero-ventral and only slightly posterior to anterior end of enteron. Vasa deferentia extending caudally from posterior extremity to each testis to unite just before entrance into vesicula seminalis. "False" vesicula seminalis not observed. Vesicula seminalis muscular, contractile and spheroidal, thin-walled when distended with sperm (Fig. 8), thick-walled when empty. Portal between sperm and granule sac controlled by sphincter. Vesicula granulorum muscular and contractile, proximally supplied with ciliated crypts, distally with rosette of granuliferous gland cells (Fig. 8) extending into genital canal of penis stilette. Penis stilette (Fig. 8) a conical tube housed in a muscular tunic, proximally truncated and crenate, distally attenuated and curved at *ca.* a right angle, opening long, sub-terminal and on convexity of apical flexure, greatest total length 50 μ, base 26 μ, stilette normally rests at *ca.* a 45° angle to longitudinal axis of body. Male gonopore ciliated and *ca.* 165 μ from posterior tip of body. Mature sperm cell (*ca.* 26 μ) highly mobile with anteriorly located hyaline granule (Fig. 7), *Nebengeisseln* lacking. Female genital system typical for genus. Ovary *ca.* one fourth as long as body. Eggs spherical and grayish brown (*ca.* 200 μ). Female genital atrium (Fig. 8) discrete, non-collapsible, finely ciliated, spheroidal. Female gonopore ventro-posterior in longitudinal mid-line, *ca.* 290 μ from posterior tip of body.

Taxonomic disposition.—Macrostomum appendiculatum var. *stirewalti* displays the specific characters of *Macrostomum appendiculatum* (O. Fabricius, 1826) Graff, 1905, but is delimited from this and other previously described representatives of *Macrostomum* as may be seen by reference to the key to the genus in Ferguson (1939–1940). In the

species the body is anteriorly blunt and posteriorly spatulate. The protonephridial system empties externally just posterior to the mouth and has a distinct caudal commissure. The sperm cell (*ca.* 50 μ) is a highly differentiated one possessing feeler, tail and body regions, plus lengthy paired *Nebengeisseln.* The penis stilette (*ca.* 59.8 μ) is relatively slender with a terminal lip or flange extending beyond the opening (see Ferguson, 1939, p. 51, Fig. 3). The numerous references to the species are given in the monograph on the genus by Ferguson (1939–1940).

Differential diagnosis.—Macrostomum appendiculatum var. *stirewalti.* Body anteriorly truncate, lacks marked spatulation, posteriorly colorless, length 1.5 mm. Rhabdites, *Stabchen* and *Rhammiten* abundant. Epidermal cilia, elongate sensory hairs and spines present. Protonephridia open dorsally at anterior tip of each testis. Vesicula granulorum with ciliated crypts and distal complement of granule glands. Penis stilette (*ca.* 50 μ) a conical tube with broad crenate base, lacking terminal lip or flange, opening at convexity of apical flexure, long and oval. Mature sperm cell elongate, threadlike (*ca.* 26 μ), lacking differentiation except for hyaline inclusion. Female sexual apparatus of usual type.

COLLEGE OF WILLIAM AND MARY—VIRGINIA POLYTECHNIC INSTITUTE NORFOLK DIVISION AND U. S. P. H. S., CRANEY ISLAND.

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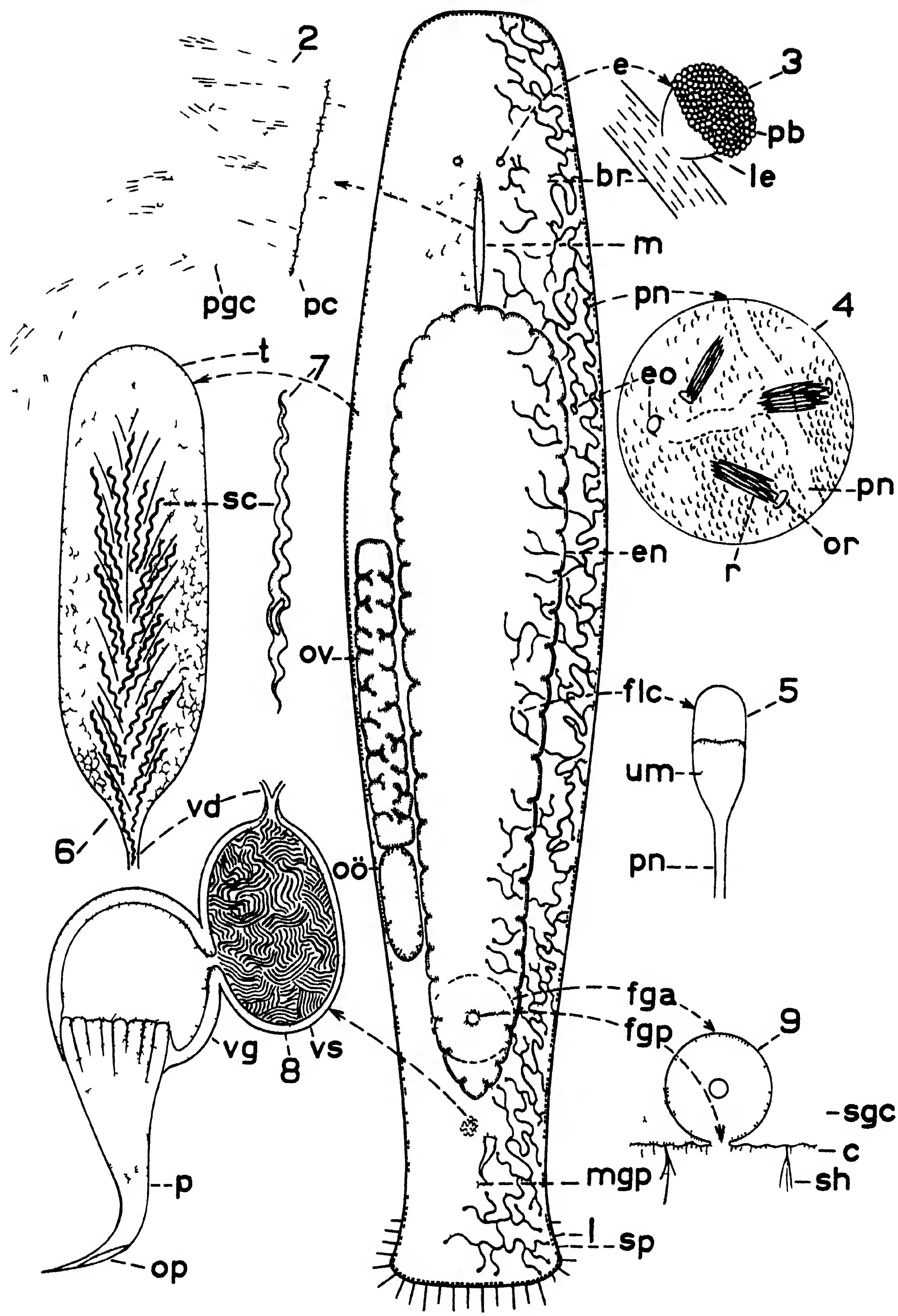
EXPLANATION OF PLATE 1

Fig. 1. Ventral view of gross anatomy. × 120.
Fig. 2. Optical section through wall of pharynx. × 750.
Fig. 3. Detail of "eye." × 675.
Fig. 4. Detail of external opening to protonephridia. × 750.
Fig. 5. Detail of terminal flame cell. × 525.
Fig. 6. Optical section through testis. × 300.
Fig. 7. Detail of mature sperm cell. × 1725.
Fig. 8. Dorsal view of male sex apparatus. × 675.
Fig. 9. Lateral view of terminal female genital apparatus. × 938.

ABBREVIATIONS USED

br—"brain"
c—epidermal cilia
e—"eye"
en—enteron
eo—external opening to protonephridia
fga—female genital atrium
fgp—female genital pore
flc—flame cell
le—"lens"
m—mouth
mgp—male genital pore
or—opening to rhabdite gland cell
op—opening to penis stilette
p—penis stilette
pb—pigment beaker
pgc—pharyngeal gland cells
pn—protonephridium
r—rhabdites
sgc—*Stabchen* gland cells
sh—sensory hairs
sc—sperm cell
sp—spines
t—testis
um—undulating membrane
vd—vas deferens
vg—vesicula granulorum
vs—vesicula seminalis

PLATE 1



ANATOMY OF MACROSTOMUM APPENDICULATUM VAR STIREWALTI N VAR

THE FOOD AND FEEDING HABITS OF THE WHALE SHARK, *RHINEODON TYPUS*

By E. W. Gudger

INTRODUCTION

Of the many questions asked about the lives and living habits of fishes, one is sure to be—"How and on what does it feed?" This question is often asked about Rhineodon along with another—"Why is it called Whale Shark?" My answer is "Because it is a whale in size (it has been measured up to 45 ft. and estimated to reach 60 ft.) and in its manner of feeding." Then I would add that like a whale it swims along at the surface with open mouth, gathering in crabs, molluscs, jelly fishes, small fishes, and all the miscellaneous organisms which we call plankton. This is sieved out by its curious gill-arch structures, which function very like the whalebone of the whalebone whales.

But more exact data are wanted and in the long years that I have been studying the whale shark, I have noted in the literature a number of incidental references to the food and feeding habits of this great fish. In addition, many accounts have come from ship's officers from various regions where whale sharks have been observed. For these latter, I am under many obligations to the courteous and efficient services of the U. S. Hydrographic Office, and it is a pleasure to make this acknowledgment.

In another article (Gudger, 1941) I have figured and have described somewhat minutely the extraordinary feeding organs of this greatest of sharks—huge mouth, small teeth, and especially the curious gill sieves which are unlike any other gill rakers in any other fish in the world. Now as a general rule it is true that the largest sharks have (in comparison with other animals) large mouths with large teeth to feed on large food or at least on large fragments of food. But it has been shown for Rhineodon (Gudger, 1941) that while it has a cavernous mouth, its teeth are only about 1/8th of an inch in length in a 30-foot specimen. The huge mouth is necessary to take in the hogsheads of water out of which the curious gill structures sieve or filter the pints of plankton and the small crabs, squids, fishes, etc., on which it feeds. And now

first of all let us see on what the largest of the sharks has been alleged to feed.

RHINEODON HERBIVOROUS?

The man who, of all writers on the whale shark, had the best chance to study this giant fish and who did little with it, was E. Perceval Wright. Wright spent six months in the Seychelles Islands, western Indian Ocean, and saw numerous specimens, photographed two and dissected two. Yet his observations are set down more or less incidentally in four publications and his photographs were never published.

Because Wright (1870) found masses of algae in the stomachs of his two dissected specimens, he came to the absurd conclusion that these fish, although true sharks, were herbivorous. But in 1879 he wrote:

> I found large masses of algae in their stomachs, so that at one time I was inclined to think it was an herbivorous shark. Probably, however, it derives its nourishment, in part at least, from minute crustaceans and other oceanic animal forms, which may be taken in along with masses of floating weed, and then ejecting the water through the strange mesh-like structures that unite the edges of the great gill openings, obtain by so doing enough to swallow.

However, this idea of herbivorous nutrition in Rhineodon has persisted long. Thus Frau Weber-van Bosse saw in 1899 and discoursed in 1905 of whale sharks in Buton Strait between Buton and Muna Islands, Celebes Group. Of Rhineodon she says, "It is one of the gentlest of the family of sharks, for the reason that, so far as is known, it lives entirely on vegetable food." This is poor reasoning. The African buffalo also eats vegetable food, but nevertheless is probably the most dangerous animal in Africa.

THE INVERTEBRATE FOOD OF RHINEODON

As noted above, Wright somewhat changed his mind to the conclusion that the whale shark feeds on molluscs, etc., tangled up in the algae. Either by observations on the living fish or by dissection after death he had abundant opportunity to get at the facts.

It is perhaps well to state here, while we are at the Seychelles, that a former correspondent of mine at Mahé informed me that the fishermen in the islands told him in 1915, and again in 1919, that the "Chagrin" (the local name of Rhineodon) fed on the "vauve," the common name for a small octopus or, as I conjecture, a small squid. This I conclude since the squid like the whale shark is a pelagic animal, while the octopus is a bottom dweller.

This is confirmed by the statement by Van Kampen (1908) that Rhineodon feeds on squids. In May, 1907, a whale shark 5.75 meters long was harpooned in Batavia Bay and dissected by Van Kampen, who found in its stomach the distinctive "Sepia-Schalen"—"cuttlefish bones." Here is the absolute proof that Rhineodon feeds on cephalopod molluscs.

Haly (1883) merely notes of a Ceylon specimen that "the stomach contained a quantity of finely-divided red matter"- probably crustacean remains. Such Raven and I found (Gudger, 1936) in the stomach of the specimen taken off Fire Island Light, Long Island, in August 1935. Because of its red color this was judged to consist of the broken up hard parts of crustacean exoskeletons. A California correspondent has seen streams of reddish feces discharged from the cloaca of a floating whale shark. Gill (1905), on the basis of the minute teeth and the gill-arch straining apparatus, deduced the general conclusion that the food of our shark consists of copepods and other crustacea, small molluscs, and other floating small animals.

How Rhineodon Obtains Its Invertebrate Food

This has heretofore been a matter of conjecture, as has been shown above. And the man who first made the conjecture was Smith 92 years ago (1849). Let us read what he wrote and see whether it coincides with the facts. He says that

> When our shark proceeds to feed, the first step it probably takes is to open its jaws to their full extent, in order to permit the mouth and pharynx to become filled with sea water. On that being accomplished, the jaws are probably closed, in order that the water shall, by muscular efforts in the pharynx, be propelled through the tubes in the branchiae, and forced thus to leave behind it whatever mollusca, &c., it may chance to contain.

From conjectures of the feeding habits and food of the whale shark, mainly made from 70 to 90 years ago, it is a far cry to the man who saw and photographed our fish in the act of swimming at the surface for the purpose of feeding on surface-dwelling organisms.

In June, 1938, Mr. E. R. Fenimore Johnson of Camden, N. J., while cruising in the Bahamas, ran into a school of about a dozen whale sharks swimming along with and around his boat. These ranged in size from about 18 to 30 feet. The individual sharks were spread out in no formation over an area of about a quarter of a mile square. An individual would swim over a small area and then turn and come back over it as if hunting for something. This sounded suspicious to me when I read

Mr. Johnson's letter, and it had looked so to him when he saw it. So he made a motion film of one or more of the sharks, and kindly gave a copy of this to the American Museum. When this picture was thrown on the screen, it seemed to me that the fish were feeding. Then when I put the film through the "movieola" so that I could stop it on any "frame" and study that picture at ease, I was convinced that the particular fish shown in certain "frames" was feeding.

When I reported this conclusion to Mr. Johnson, he answered that

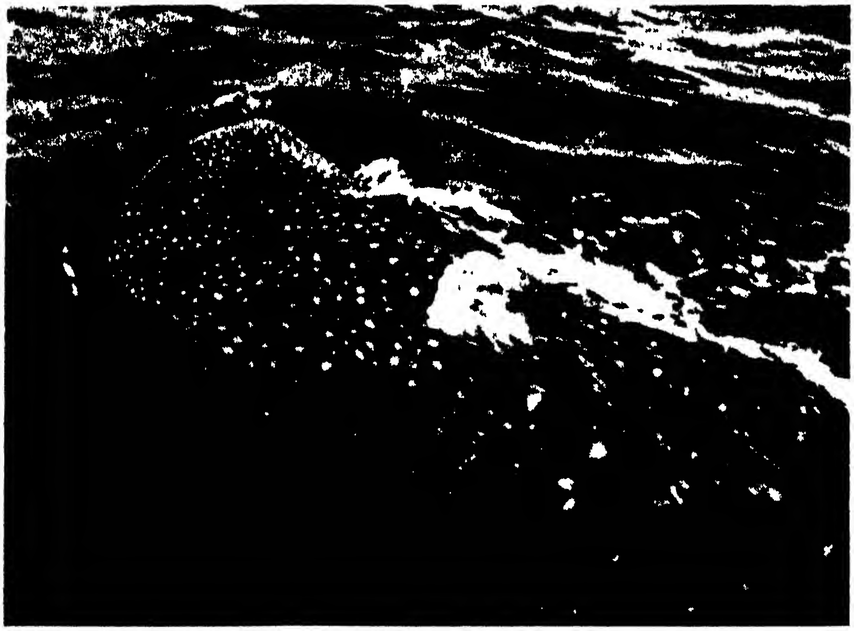


FIG. 1. The Whale Shark feeding at the surface of the sea

these whale sharks were certainly engaged in feeding. He said that a fish would swim for a few minutes with its huge mouth open and with its upper jaw about at the surface of the water. Then the fish would dive to a shallow depth for a brief interval and then come to the surface and repeat the manoeuvre. There is every reason to believe that it was feeding. Fig. 1 is one of the "frames" from Mr. Johnson's film showing this feeding. Curious to know what the fish could be seeking, Mr. Johnson dipped up pails of the sea water, but naked eye examination showed only scattered jellyfishes about 15 mm. in diameter. These surely made poor provender for this huge fish.

But there can be no doubt that these whale sharks were feeding on plankton at or near the surface of the water, and Mr. Johnson's film

gives the ocular proof. Thus he becomes the first person in the world to establish definitely by observation how Rhineodon obtains its invertebrate food. How the small invertebrate organisms are filtered out of the water has been carefully described in the article (Gudger, 1941) on the gill-arch structure, and need not be repeated here.

RHINEODON FEEDS ON FISHES

Rhineodon is a sluggish fish and does not use up energy like the more active swordfish, the spearfishes, the tuna and above all the bonito. This latter very active fish, according to John Davy, has a temperature nearly 10°C. higher than the surrounding water. On the other hand, the whale shark is the largest thing that swims the seas—the whales only excepted—and, even when loafing along, his huge body because of its very size, must use up much energy. To furnish this energy, a very large amount of food must be taken in.

The whalebone whales are also plankton-feeders, are rather sluggish swimmers, and have huge bodies—much larger than the whale shark's. To keep their great engines going, they too must have large quantities of food. This, because of their efficient oral sieving apparatus (plates of hair-fringed whalebone hanging from the roofs of their mouths), they obtain by straining it from great quantities of sea water. Now, the whalebone whales are high-latitude dwellers, and in those cold waters are found their invertebrate food in astronomical numbers and vast quantities. This, designated as "brit" by the whalemen, consists of small crustaceans of reddish color which occur in such great swarms as to discolor the surface of the sea for acres—the so-called "tomato-soup sea" of common parlance. So dense are these aggregations of this whale food in colder waters that, out of a "brit"-containing hogshead of water, gallons of food are obtained. Thus the whalebone whale is enabled to get the food required to keep his locomotor apparatus active.

In contrast, the whale shark lives in tropical and subtropical waters, and in the warm currents flowing out of and away from these waters. But in these warm waters there are no such aggregations of crustacean food for the whale shark as there are for the baleen whales in colder waters. Sometimes comparatively small and scattered aggregations (occasionally 10 feet in diameter) of crustacea, jellyfishes, etc., are found where whale sharks live, but these are so few and so scattering that the whale shark out of hogsheads of such water could obtain only pints of food. Even sluggish as the whale shark is, it could hardly be

expected by this feeding to get enough invertebrate food to keep its great engine going. Invertebrate food is not enough. Consequently I have long believed that Rhineodon must feed on small fishes. For this belief the proof is now at hand.

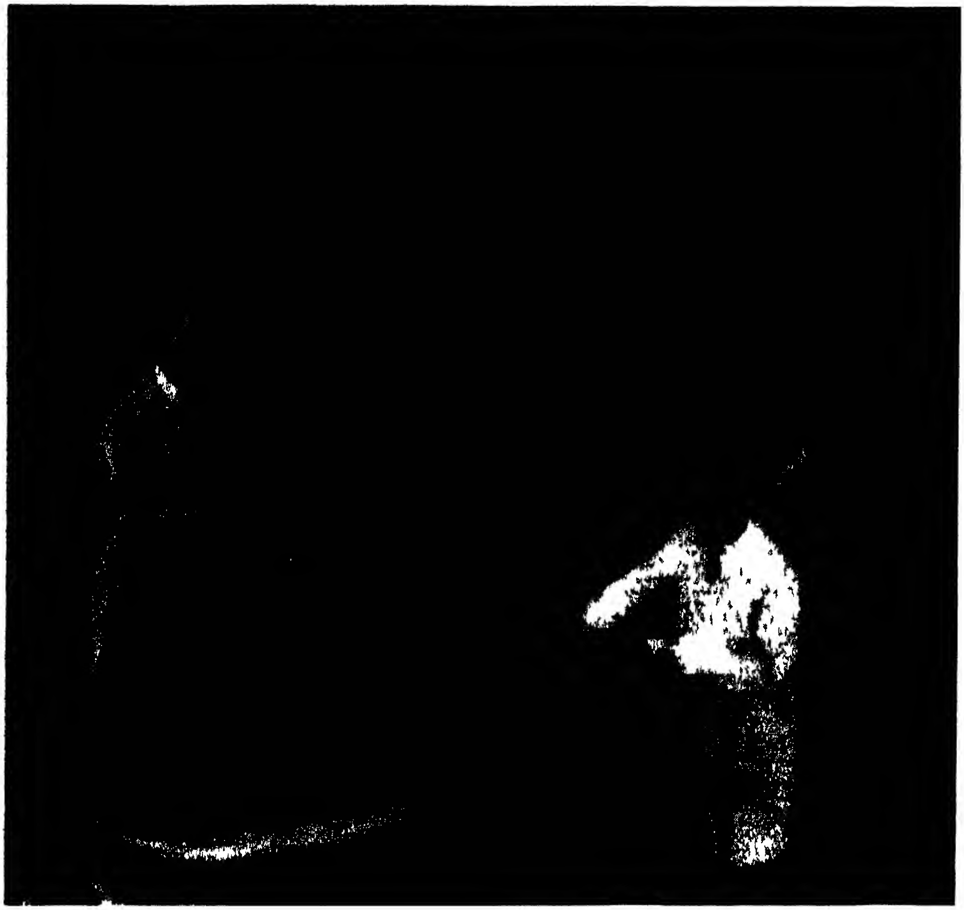


FIG 2 The mounted skin of Rhineodon in the American Museum is having its spots restored

Miscellaneous Records of Fishes Eaten

The earliest accounts are merely scattered incidental notes and will be collected under the heading "Miscellaneous."

Tang.—So far as I know, the first writer to allege that the whale shark feeds on fishes is Günther. He wrote (1880, p. 324) that "It has been stated to feed on tang, an observation that needs confirmation." And it certainly does, for, though tang go in schools, they live around coral

reefs and hence would be safe from Rhineodon. While the tang is a rather small fish—6–12 in. long—it is a laterally-compressed and rather deep fish, its depth being contained in its length 1.5-2 times. It is a bit difficult to imagine such a fish going down the relatively small esophagus of the whale shark.

Sucking fish.—Kishinouye (1901) states that in the stomach of the specimen taken off Japan in 1901 a sucking fish was found. However, since the slender sucking fish are known to affix themselves to the upper part of the cavernous mouth of the whale shark, it would seem that this one had been swallowed by accident and not as a normal article of food.

Gobies, *Saurida.*—In 1908, Van Kampen published his brief note on the food of a Rhineodon taken in Batavia Bay, Java. In the stomach he found some small fishes—Gobies and one or more specimens of the coast-dwelling Synodontid genus *Saurida.*

Rhineodon Associates with Large Fishes but Feeds on Sardines

Now come accounts from five far-distant parts of the three warm oceans of an extraordinary association of Rhineodon with relatively large fishes—fishes too large for his small throat—but of his feeding on small fishes only. These small fishes are described as "sardines" and such they sometimes surely are, but the term probably covers all other small fishes taken in.

Whale Shark and Caranx at the Seychelles

The first dependable information as to the fish-eating proclivities of our great shark came to me from a valued correspondent at Mahé, Seychelles Islands, Western Indian Ocean. First in 1914, again in 1915 and 1919, and last in 1925, Mr. P. R. Dupont, Curator of the Botanic Station, wrote that the most reliable fishermen of the Seychelles reported that the "Chagrin" was associated with the "carangue balo," a caranx, but that it did not feed on it. Further questioning of the fishermen elicited the information that in the summer the SE tradewinds brought inshore to the islands great schools of "tauve," a kind of sardine, and of the caranx (*Caranx gymnostethoides*) which fed on the sardines. Furthermore they told him that the whale sharks were always at this time associated with the caranxes and that they also fed upon the sardines. So constant was the association of whale shark and caranx that the presence of a whale shark in the distance was a sure sign that the caranxes and sardines abounded, and when they saw it the fishermen set out with their nets confident of good fishing for the caranxes.

In every letter, Mr. Dupont warned me that this was what the fishermen reported, and that he himself had no proof of it whatever. However, from now to the end of the chapter, we will have the most amazing evidence in support of this "fisherman's tale."

Rhineodon and Bonito off Japan

Kishinouye has already been cited as having noted a sucking fish in the stomach of a Rhineodon taken off Cape Inubo, Japan. Seeking further information about the whale shark in the Kuro Sivo, I wrote Prof. Kishinouye and from his answering letter the following interesting data are excerpted:

> I am told that Rhineodon is quite common in the fishing-grounds of striped bonito off the eastern coast of Hondo.
>
> In the summer months, when the bonito fishing is busily carried on, the large shark comes to the surface of the sea, and seems to remain there basking. Around these sharks, the bonito crowd together.

At the time of receipt of this letter, I was busily engaged with other studies and being obsessed with the idea that the bonito had crowded around and probably under the whale shark to get in its shadow or to hide from enemies, I unfortunately did not pursue the inquiry further. Such inquiry is now impossible since Prof. Kishinouye has died. However, in the light of data already set out, it is more than likely that the whale sharks were seeking their food among the bonitos. Incidentally it may be noted that the striped bonito was the principal catch in the pound net off Fire Island Light into which the whale shark (previously referred to) blundered in 1935. It seems not improbable that here as off Japan whale shark and bonito were associated in seeking food.

Whale Sharks and Bonito in Cuban Waters

Dr. Luis Howell Rivero, head of the department of fishes in the Museo Poey of the University of Havana, writes that—"It is common knowledge that in Cuban waters, whale sharks and bonitos feed on and in schools of sardines. Upon coming to such a school, the whale sharks stand up vertically to feed. The bonitos do the same thing, leaping around to feed on the sardines. This fact causes the illusion that the whale sharks are feeding on the bonitos also." He also states that this association and feeding behavior have been observed in three Cuban localities, that the persons reporting these matters are personally known to him and that their veracity is unimpeachable. The accounts for these localities will now be presented.

Off Havana.—My first intimation of this interesting behavior of these fishes in this region came from Dr. W. H. Hoffmann of the Laboratorio Finlay in Havana. Dr. Hoffmann is a keen student of Rhineodon and has supplied me with invaluable data. He writes that the whale shark comes to the Havana region in the winter months along with great schools of sardines on which it feeds. These data came to him from different fishermen but as will be seen they agree in all essential details with accounts from other regions.

Later, other fishermen reported that in January and February the sardines in great schools come inshore from the Gulf Stream and that Rhineodon follows them. One fisherman stated that the sardines in the bays often leap out of the water as a result of the attacks by various predatory fishes. Another reported that he had seen the big shark feeding on the sardines out in the open sea, filling his mouth full and then swallowing them. Still another fisherman stated that he and his fellows had seen the whale shark standing nearly upright in a school of sardines and letting the small fishes jump into his open mouth. That this is not an isolated observation will now be seen.

In November, 1936, Dr. Carlos de Cardenas of Havana called at my office to discuss the whale shark. He told me that this feeding of our shark in a shoal of fish is a well-known phenomenon in Havana waters, but that it is reported that these fish are bonito. I suggested that Rhineodon, with the small gullet reported by Smith in 1849, could hardly swallow bonito which run from 8 to 15 pounds, and I urged that he make further and if possible personal observations. Recently Dr. Cardenas has written me on the subject as follows: "The whale shark is found in Cuban waters during the winter months feeding perpendicularly in schools of bonito and sardines. The opinion of fishermen here is that the bonito jump into the whale shark's mouth in trying to catch the sardines. At this time of the year it is rare to find a school of bonito in which there is not a whale shark in the middle." Dr. Cardenas states that various attempts have been made to take moving pictures of this feeding. And he has kindly promised that, if he learns of a successful attempt, he will endeavor to procure and send a copy of the film to me. This is a great desideratum.

Dr. Rivero, as noted above, corroborates the reports of Dr. Hoffmann and Dr. Cardenas for Havana waters. He has kindly communicated like information as to the behavior of all these fishes in two other localities. These now follow.

Off Manzanillo.—Dr. Rivero has kindly supplied me with data for

whale sharks and bonitos fishing in this locality, which is on the great bay on the SE shore of Cuba. He states that:

> The Manzanillo records, which have been furnished by a medical doctor and fishing sportsman, state that in open waters, and also when schools of sardines approach the shore, the whale sharks have been seen to stand upright to feed on them. Then the bonitos, chasing the sardines, leap around and among them, making a great disturbance and feeding on them also. The sardines are very abundant here and this behavior has been observed more than once.

Off Gibara and Vita.—These localities are on the northern coast of the far eastern end of Cuba. Off these localities 40-foot whale sharks have been harpooned. The accounts of the occurrence and behavior of whale sharks, bonitos and sardines in these waters are less detailed than those which precede but Dr. Rivero states that the behavior of these fishes is essentially the same and that I may list these localities on his authority.

This behavior of these fishes is an exceedingly interesting phenomenon. Whale sharks and bonitos are plainly competing for food—sardines. When the whale shark gets his mouth full of the small fish, it is possible that he may elevate his head to facilitate the passage of water out through his gill slits. Here then we get the vertical position. In the meantime the savage bonitos charge into the school of sardines, and they and the terrified little fish are leaping and splashing—making a great commotion in the water. In this leaping of the bonitos after the sardines, the larger fish are more visible and would surely catch the eye, while the little sardines would not be noticed—if the fishermen are at a little distance. All this phenomenon then, to a non-scientific and non-critical observer at some distance, would appear as if the bonitos were leaping into the mouth of the great shark.

What I cannot understand is the alleged vertical position of the open-mouthed whale shark. If Dr. Gardenas shall be so fortunate as to get a motion film of this performance, critical examination of this frame by frame in a "movieola" will demonstrate the facts.

Rhineodon and Tuna in the Bahamas

Capt. Tom Gifford, the well known fishing captain and guide, has communicated an interesting observation of the apparent feeding of Rhineodon on sardines. In June some years ago, he was fishing for

marlin in the edge of the Gulf Stream off Turtle Rocks, near Bimini, Bahamas, when he saw a whale shark feeding along with tunas.

We were short of bait and ran over to a large school of small tuna that were striking bait on the surface of the sea, which was quite calm. Upon approaching the school, we saw a dark solid mass about 30 feet long by about 12 feet deep, through and around which the tuna were darting, and through which two or more sharks, some six or seven feet long, were swimming lazily. This compact mass was composed of millions of small black and silver sardines.

As the boat approached to within 8 or 10 feet of the sardines, the sharks and tuna left. I was handling the boat from the control on the top deck, and therefore had a clear view of what took place. I first saw the whale shark when he was about 20 feet down. He swam upward at an angle of about 20 degrees straight through the school of sardines. Turning far more quickly than I had thought such a huge fish could, he came back and once more swam through the sardines. As his huge bulk swept through the school, it had a tendency to scatter the bait on the surface of the sea. On his third trip through the school, the bait fishes were much spread out and were able to swim out of the big fish's way. He then turned off and settled down at once.

Capt. Gifford cannot say that he saw the great shark take sardines into its mouth nor did he see any dropping from its jaws. But he is unable to interpret the trips of the shark through the school as having any other purpose than that of feeding. However, this observation so closely parallels those previously set out and others to be found later herein, that it is to me a sound conclusion that like the tuna the whale shark was enjoying its favorite food.

There is now to be given here a brief account of the concentrated occurrence of the whale shark in the north-central Gulf of Mexico. The data came via the U. S. Hydrographic Office. Sixty-eight whale sharks had been seen from six steamers on eight trips in a rectangular area *c.* 120 x 170 miles or more narrowly within a circle having a radius of *c.* 87.5 miles. This concentration of ships is due to a converging of steamer lanes from Texas oil ports for the boats to swing around Florida in the Gulf Stream before straightening out on a northern course. This concentration of whale sharks can only be explained on the basis that there was here a great concentration of their food. What this food was cannot be said, since the ships were moving at from 12 to 16 knots, and while the officers saw the big fish and reported them, they could hardly have noticed any accompanying smaller fish—either tunas or sardines.

Whale Sharks and Tuna off Lower California

The whale shark has been recorded from the Gulf of Lower California since 1865. My accounts of its occurrence off the west coast of Lower California and around Cape San Lucas date from about 1925, and came from the reports of anglers fishing in those abundant waters. As time has gone on, anglers have more and more resorted to this region and they have reported many occurrences of our great shark. But the great development of tuna fishing all the way down the coast of the peninsula to and below Cape San Lucas has brought more accounts of the abundance of whale sharks, and of their association with the tunas. This phenomenon will now be set out fully and will throw a flood of light on other associations not clearly understood before.

My earliest knowledge of the association of whale sharks and tunas in this region came in a letter from Mr. Mack Sennett, the motion picture producer. In 1926, Mr. Sennett was fishing and also making submarine motion pictures of various fishes (including the whale shark) in the waters around Cape San Lucas and in the lower Gulf. In his letter, Mr. Sennett stated that he had found great numbers of tunas swimming about a 65-foot whale shark, and that about 20 were in close attendance on one shark when his boat came up to photograph it.

Mr. P. Nielsen of Nestor, California, wrote in June, 1937, that "The whale sharks are often seen in the summer months from Hipolito Point south. They're often found with a school of tuna, and fishermen will frequently stop and throw live bait overboard when a shark is sighted. This often results in tuna coming to the surface." Further correspondence with Mr. Nielsen brought, in September, 1937, this additional information. "The big spotted sharks will often circle the fishing vessels, while they are drift-fishing for tuna, and they frequently come within a few feet of the vessel. I've observed them eat the small fish used for bait—anchovies and sardines—when these are dead, but I have never seen one of these sharks catch a live one, and I believe that they are much too slow to do so."

Next comes valuable data kindly communicated by Capt. J. M. O'Niel, master of the fishing vessel "Pacific Queen" out of San Diego, California. He writes that:

From April 9 to 14, 1939, we were fishing for tuna on Gorda Banks off the tip of Lower California, and each day we had at least one whale shark circling around us, under us, and everything but over us. We found that the tuna were always around these sharks, and that the sharks circled around our boat in order to eat the excess live bait that

we throw over to attract the tuna. Twice I had one of these whale sharks come alongside right under me, open its mouth in front of a small school of this bait and seem to exert a powerful suction, since the bait was drawn into the shark's mouth and he would swim on. Their movements are very slow and leisurely. These fish were 40 and 50 feet long. We became so accustomed to their cruising around us that they did not cause any interest after the first day or two.

Again under date of Sept. 1, 1939, Capt. O'Niel added these further interesting data on the feeding of our fish:

While fishing on the 100-fathom curve about 25 miles south and west of Cape San Lazaro, Lower California, on July 16 and 17, 1939, each day we sighted whale sharks, and, profiting by previous experience, we headed for them and when close aboard (say 20 or 30 feet) started throwing over live bait. The results were as previously experienced on Gorda Bank earlier this year, and we caught about five tons of yellow-fin tuna, which seemed to school up around the whale sharks. In appearance and action these sharks were exactly as described in my earlier report this year.

In this tuna fishing, to attract the tunas, live bait, the sardine (*Sardinia caerulea*), is used off Lower California. These sardines go in huge schools, are taken in large seines, are carefully transferred in dip nets to capacious tanks near the stern of the fishing vessel and these tanks are provided with a copious supply of fresh salt water. When a whale shark is sighted, the boat moves over and close up to the shark. Lowered over the rail aft are metal racks or stages on which the fishermen stand. They fish with heavy rods whose stout lines end each in a beardless feather-covered hook. When the fishermen reach a school of tuna, with or without an accompanying whale shark, the live bait is ladled overboard from the tanks. The ever-hungry tuna fight for the bait, but, as Mr. Nielsen and Capt. O'Niel state, the whale sharks not infrequently get their share. The technique of tuna fishing—with the whale shark unfortunately missing—has been admirably described and figured by John Tee-Van (1938). To his article the interested reader is referred.

The bait fishes, sardines and anchovies, are agile little fishes, and one could hardly expect the clumsy, slow-moving whale shark to catch individuals as such or as parts of a small school with its numbers somewhat scattered. On this point, recall Capt. Gifford's observation in the Bahamas. But these bait fishes go in enormous schools and off Lower Californian and Mexican coasts are fished for at night with a seine sometimes measuring 720 feet long and 72 feet deep. So large are the

schools and so closely packed are the fish, that sometimes the net is carried away by the weight and boats and men are endangered.

In the matter of the association of whale sharks and large fishes and of their mutual feeding on small fishes, it must be noted that the accounts cover a time interval of 60 years—from Günther (1880) to the present—and that they came from widely separated parts of the three central oceans. Furthermore, emphasis must be laid on the fact, that when multiple accounts come from certain restricted regions, as off Havana or Lower California, they were sent in by men who did not know that others were reporting from the same locality. Finally it must be re-emphasized that all accounts, from whatever ocean and source they have come, corroborate each other on all essential points—all dovetail together.

With these facts before him, the reader is prepared to believe that the whale shark feeds on such small fishes as go in schools, and that he can each time take in a large mouthful. Easy then is it to understand the association of whale sharks and tunas—they are feeding together on sardines in the Bahamas and off the west coast of Lower California. And so are bonitos and whale sharks off Havana, Cuba. This too explains the association of whale sharks and bonito off Hondo, Japan, and of whale sharks and the carangid fish at the Seychelles.

How Rhineodon Takes in the Sardines

This is so simple that it hardly needs to be categorically set out. Yet, for completeness and to emphasize the process, it will be done. It is greatly to be regretted that no photograph has ever been made of Rhineodon in the act of feeding on sardines, and that no one has been able to dissect a whale shark and find large numbers of sardines and other small fish in its stomach. Some day both these objectives will be attained and then the case will be closed.

The method of in-taking of invertebrate food has been figured and described. The great shark swims with slightly open mouth at the surface of the sea. Water enters by the mouth and passes through the sieve-like gill arches leaving behind all except the smallest organisms. The foodstuff passes down the throat, while the water, coursing through the sub-gill-arch cavities, passes into the sea through the gill slits. Probably the largest amount of food materials thus gathered consists of swimming crabs and small squids.

The in-taking of vertebrate food is considerably different. It has been described by various men. Two have described the catching of sardines by Rhineodon off Havana and off Manzanillo, Cuba. One reported that he had seen the big shark feeding on sardines, filling his mouth full and then swallowing them. Here, unfortunately there is a painful lack of details. Another had seen the great shark standing vertically in a school of sardines and apparently letting the small fish jump into its mouth. Then there is Dr. Cardenas's statement from his fishermen that the whale shark stands vertically in schools of bonito which jump into the whale shark's mouth while pursuing sardines. My explanation of this alleged feeding has been given elsewhere and need not be repeated here.

A very accurate description and the simplest explanation of the taking in of sardines is given by Capt. O'Niel. In describing the throwing over of bait to attract tuna off the coast of Lower California, he stated that the shark as well as the tuna would come near the boat to feed. Then the great shark would "open its mouth in front of a small school of bait and would seem to exert a powerful suction since the bait would be drawn into his mouth and he would then swim on." Presumably this is just what Rhineodon does when he approaches a free school of sardines out in the sea. This is the way in which any large fish takes in food made up of relatively small fishes, i.e., thus the wide-mouthed angler, *Lophius*, takes in small fish, several or one at a time.

Since the above was written there has come, via the U. S. Hydrographic Office, some exceedingly valuable corroborating data. Capt. R. W. Mindte of San Diego writes that it is well known that whenever a whale shark is sighted it will be surrounded by yellow-fin tuna, and the fishermen head for it at once. Then he gives the following definite evidence—first (the only account for California waters) that the fish stands vertically in the water, and second that it feeds by suction. He states that:

> Often these sharks appear to be floating tail down in a vertical position in the water with the mouth submerged about one foot in the water. On one occasion while throwing live bait overboard, we noticed that any bait that fell within 3 or 4 feet of the shark's mouth was sucked in by a tremendous suction. We could even see the bait trying to swim away from the mouth, but the pressure was too great. The shark's mouth at this time opens vertically about eight or ten inches.

AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK CITY.

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ANNUAL REPRODUCTIVE CYCLE OF THE MALE FENCE LIZARD

By Paul D. Altland

Plate 2

INTRODUCTION

In lizards, as in other animals that mate but once each year, there are seasonal variations in the size and microscopic structure of the testis. It has been demonstrated that various members of the Lacertilia show different types of reproductive cycles. Herlant ('33), and Regamey ('35) find that lizards of the genus Lacerta begin spermatogenesis in late summer and spermiogenesis in March, and that the breeding season in May is followed by a period of involution, which is completed by August. In an experimental study on *Eumeces laticeps*, Turner ('35) reports that control animals show spermatozoa in April, breed in May, and pass through a season of low sexuality from October to December. Another type of cycle is found by Blount ('29) in the horned toad (*Phyrnosoma cornutum*), in which spermatogenesis begins in May and ends during the breeding season in mid-August, after which the testis remains in a quiescent state until spring.

During the course of an investigation on the relationship of the hypophysis and testis of the fence lizard, *Sceloporus undulatus*, it was found that the annual reproductive cycle is unlike that found in the other North American lizards studied (Eumeces and Phyrnosoma). Since it seems desirable to make this information available, a complete account of the weight of the testis in each month of the year, and an analysis of the microscopic structure is given.

MATERIALS AND METHODS

The fence lizards, *Sceloporus undulatus undulatus* (Latreille), were collected in the Duke Forest, Durham, North Carolina. During October a large number of specimens were caught, housed in out door cages, and fed upon meal worms and fly larvae. With the approach of winter the lizards hibernated under the leaves and twigs in the con-

tainers. In this manner a source of lizards was maintained during December, January, and February. This phase of the work was carried out in the zoological laboratories of Duke University, Durham, North Carolina.

Differences in the size of the right and the left testes were noted, but the variation was so slight and inconsistent that it was not considered to be of any particular concern. Both testes were removed: one was preserved in Bouin's fluid, carried to 70% alcohol, and weighed; the other was fixed in Allen's modification of Bouin's fluid for a study of the cytology of the testis. All tissue was embedded in paraffin and cut at 6 and 8 microns. Some of the tissues were stained with Ehrlich's hematoxylin and counterstained with eosin; others were stained with Heidenhain's iron hematoxylin followed by 1% phosphomolybdic acid and methyl green.

In making the table of the gonadal weights and the diameters of the seminiferous tubules, animals were chosen to represent regular intervals throughout each month. The body weights given for all lizards are the actual live weights.

OBSERVATIONS

The testis of the adult fence lizard is an ovoidal organ when observed intact in the animal, but after removal it becomes almost spherical. Its light color is maintained throughout the year. The left testis lies just anterior to the kidney, and the posterior margin of the right testis begins near the anterior limit of the left. The testes are suspended in the body cavity by mesorchia which are attached to the pigmented peritoneum. The connective tissue surrounding the testis, the tunica albuginea, is continuous with the fibrous tissue found between the seminiferous tubules. This connective tissue is very thin when the organ is enlarged, and as the testis decreases in size during the regressive stages of the cycle, this fibrous cover becomes thicker (figs. 1 and 5). The mesothelium surrounding the connective tissue does not undergo any change during the enlargement.

A compact gland, associated with the adrenal complex of the fence lizard, lies dorsal to the testis and is enmeshed in the supporting tissue. From July to April a fat body is found associated with the testis; its yellow color stands out clearly against the black peritoneal background. The size of this fat body is greatest from August until October; after this period it gradually decreases in size until it completely disappears some time after emergence from hibernation. An account of the uro-

genital system will not be presented at this time, but will be considered in relation to some experimental work in progress.

The arrangement of the seminiferous tubules is very irregular, only a few tubules in a transverse section through the gland being cut in a complete cross section. The seasonal alteration in the size and microscopic structure of the testis is very pronounced in the fence lizard. Spermatogonial divisions are abundant in July and August, but are encountered less frequently in September, October, and November. Spermatogenesis begins in August, with an increase in the size of the spermatogonia and the appearance of the process of synapsis. During September and October the primary spermatocytes with conspicuous pachytene, diplotene, and diakinetic stages, occupy over half of the tubular diameter. Secondary spermatocytes and spermatids are forming a complete layer around the lumina of the tubules. Spermatozoa are not usually found, although occasionally small groups of ripe spermatozoa appear in these autumn testes. The nuclei of the Sertoli cells are scattered here and there along the basement membrane, and they are differentiated from the surrounding spermatogonial nuclei by a lighter staining chromatin material. Very little intertubular space is present, but blood vessels, endothelial nuclei, and fibrous connective tissue may be identified. Interstitial cells have not been observed (fig. 1).

The onset of spermatogenesis is marked by a general increase in the weight of the testis and in the size of the seminiferous tubules. During the period of rest in July the average weight of the testis is 16 milligrams, which is the lowest weight recorded throughout the yearly cycle. The diameter of the seminiferous tubules is smallest in July, measuring approximately 110 micra. In August the average weight increases to 51 milligrams. During September and October there is considerable variation in testis weight, this being due to the action of the new spermatogenic cycle. In view of this evidence it seems that some testes respond more readily than others to the stimuli initiating testicular activity.

During November there is a change in the predominating cells in the tubules. Instead of the primary spermatocytes being most numerous, as they are in September and October, the secondary spermatocytes and spermatids are now most abundant (fig. 2). Ordinarily there are no spermatozoa present. In November the average weight of the testis is 278 milligrams, the highest average for any month throughout the annual cycle. A testis weighing 297 milligrams was taken from an animal on April 2nd. Scattered groups of spermatozoa were observed

in each tubule, and a predominance of spermatocytes and spermatids was evident, a condition typically found in January and February.

Evidence of the normal appearance of spermiogenesis is encountered in December, and as a result small clusters of ripe spermatozoa are associated with the secondary spermatocytes and spermatids in every tubule. It is very difficult to detect Sertoli cells in these enlarging tubules. Metamorphosis of the spermatids continues slowly during January and February, and spermatozoa soon completely line the lumina of the tubules (fig. 3). Spermatogonial divisions are of rare occurrence in the hibernating season.

TABLE 1

All data have been obtained from adult male lizards weighing between 9.2 and 9.8 grams.

MONTH	NUMBER OF ANIMALS	WEIGHT OF THE TESTIS IN MILLIGRAMS			DIAMETERS OF THE SEMINIFEROUS TUBULES IN MICRA		
		Min.	Ave.	Max.	Min.	Ave.	Max.
January	7	170	215	288	261	275	294
February	7	160	195	210	251	261	302
March	7	115	165	252	232	257	278
April	20	115	135	297	220	232	249
May	16	60	91	110	180	204	215
June	12	52	56	61	142	153	175
July	9	14	16	25	107	110	131
August	10	29	51	69	109	145	170
September	11	48	92	185	119	160	197
October	15	220	232	248	261	286	318
November	10	261	278	298	262	293	320
December	5	220	240	275	225	285	312

In March, April, and May a marked change in the nature of the testis is noted. There is a gross transformation of spermatids to form spermatozoa, but in figures 4, 5, and 6 it is clearly shown that not all of the spermatids mature at this same time. Masses of spermatozoa line the lumina of the tubules, becoming so numerous that an association of spermatozoa with the Sertoli elements has not been clearly demonstrated (fig. 4). However, the central location of Sertoli cells in July and August suggests that they may have been present in May also, but they were apparently obscured by other cells. In May spermatogonial divisions are found only rarely. Despite the continued activity of the primary spermatocytes, the enlarged cord size is not maintained;

this is due in part, at least, to the large quantities of spermatozoa that are transferred to the epididymis and vas deferens, which are highly developed at this time. The sexual segment of the kidney and the femoral organs are also greatly enlarged during this period of high sexual activity. The average weight of the testis continues to be reduced until in May it is only 91 milligrams; during this same period the average diameter of the seminiferous tubules is reduced to 204 micra.

Copulation has been observed in May and early June. After the breeding season many spermatozoa still remain in the testis and ducts (figs. 5 and 6). Except for a layer of spermatogonia along the basement membrane, almost the entire cellular structure in many tubules has disappeared by July. There is no evidence of degeneration of spermatogonia; in fact, mitoses are very abundant, apparently building up the germinal epithelium for the next cycle. The lumen appears quite large when compared with the area occupied by the cellular elements. Occasionally a few scattered spermatozoa surrounded by material sloughed off during the maturation process may be found in the lumen, and some primary spermatocytes are also a part of the remaining cellular structure.

In June and July the Sertoli cells are scattered among the spermatogonia next to the basement membrane, and occasionally they are found in the center of the tubules. The Sertoli cells are spherical and well-defined, instead of being compressed by adjoining cells, as is the case from September to June. The cell membrane of these cells stands out sharply. It is characteristic to find an ovoidal mass very closely associated with the large spherical nucleus. Although the testes were not prepared to demonstrate cytoplasmic inclusions, it appears as if this material corresponds to the fatty inclusions described by Herlant ('33) and Regamey ('35) in the Sertoli cells of Lacerta. Mitoses have not been observed in the Sertoli cells.

In August the seminiferous tubules are dominated by resting spermatogonia, although mitotic stages are quite numerous. There is no lumen present, the central portion of the tubules being filled with cells, some primary spermatocytes probably remaining from the previous cycle, and others beginning the new (fig. 7). Apparently all of the spermatozoa that were not released in the breeding season have been completely destroyed by this time. An examination of the intertubular areas indicates that there are no interstitial cells present. Well-defined interstitial cells have been found in the testis of the blue-tailed skink,

Eumeces fasciatus, by using the same methods employed in the preparation of the fence lizard material.

In males weighing from 3 to 8 grams the seminiferous tubules are usually small from April until August. The testis weight of such specimens varies from 10 to 30 milligrams. The gland is in an immature condition, showing one or two layers of spermatogonia, scattered Sertoli cells, and no perceptible lumen.

DISCUSSION

The testis of *Sceloporus undulatus* has one sexual cycle during the year. Spermatogenesis begins in August and continues until July. During the first three months of growth primary spermatocytes, secondary spermatocytes, and spermatids are formed in great numbers. Spermiogenesis begins in December, and by April the seminiferous tubules contain many spermatozoa. The breeding season occurs in May and early June, after which there is a period of involution and rest before the onset of the next cycle. In the course of this activity there is wide variation in testis size. In late July the testis is very small, growing to the maximum size in about three months, and from this time until the end of the yearly cycle there is a gradual diminution in size.

The spermatogenic cycle of *Lacerta muralis* and *Lacerta serpa*, as reported by Regamey ('35), are essentially the same as that given for *Sceloporus undulatus*, although there are some minor variations. At the beginning of August, when the seminiferous tubules of the fence lizard are largely taken up by spermatogonia, a few normal primary spermatocytes are found. One cannot be certain whether maturing cells still remain from the last cycle or not, but there is such a great development of primary spermatocytes in September that they probably represent the first of the new series. In Lacerta Herlant ('33) finds dividing primary spermatocytes in July, and spermatids in August, which he apparently considers to be a part of the new cycle. From December through the remainder of the cycle the testis of the fence lizard shows a gradual reduction in the diameter of the seminiferous tubules, while in Lacerta the tubules do not begin to decrease in diameter until the end of March. In both cases the decrease in the tubule size is correlated with spermiogenesis and the release of spermatozoa. The spermatozoa that occur in October and November are probably stimulated by some unseasonal factor, and their presence is not associated with a false breeding season, as has been reported for the musk turtle (Risley, '38) and the

salamander, *Triturus viridescens* (Adams, '40). Regamey ('35) considers this autumnal spermiogenesis to be abortive and of little importance in *Lacerta agilis*. The normal spermiogenesis occurs in the spring.

Forbes ('41) reported that in *Sceloporus spinosus floridanus*, which were kept in the laboratory at room temperature, the testis showed spermatogenesis resembling the full breeding condition at the end of March. He considered it likely that active spermatogenesis begins after February 15th. Turner ('35), working with *Eumeces laticeps*, and Clausen and Poris ('37), with *Anolis carolinensis*, found that the breeding season occurs in the spring and that the testis is relatively inactive during the winter. Although these workers were not concerned with the complete annual cycle, it is apparent from an analysis of their work, that active spermatogenesis does not occur until early spring. In *Sceloporus undulatus* maturation divisions are prominent as early as September. Blount ('29) in a study of the testis of the horned toad, *Phyrnosoma solare*, found that spermatogenesis appears first in May and then proceeds rapidly, with mature sperm occurring within several weeks. The height of spermatogenesis is in mid-July, with breeding activity prevalent about the 15th of August. Among lizards this is the only instance, so far as the author is aware, of normal breeding occurring at any other time than the period following the spring awakening. According to Risley ('38) the musk turtle, *Sternotherus odoratus*, begins spermatogenesis in May, and by September or early October the tubules are filled with sperm. A false breeding season may occur in the fall, but normally sexual relations take place about the middle of May. It has been noted that the seasonal variation in the quantity of the spermatic tissue given by Oslund ('28) for *Bufo vulgaris* and *Rana temporaria* very closely resembles that found in Sceloporus.

During June and July the spherical Sertoli cells are much more conspicuous than when they are elongated due to compression by adjoining cells. Turner ('35) also noted that the Sertoli cells of the testis of *Eumeces laticeps* were brought into greater prominence through the atrophy and aplasia of the cells of the previous reproductive cycle. In the work of Risley ('38) on the musk turtle it has been found that after the liberation of spermatozoa in June, the entire lumen of the seminiferous tubules fills with the cytoplasm of the Sertoli cells. After emergence from hibernation, when the tubules are filled with spermatozoa, the Sertoli nuclei are located well out toward the center of the tubule, away from the basement membrane, and they outnumber the

spermatogonial nuclei in a ratio of 6 or 8 to 1. In Sceloporus the Sertoli cell nuclei have not been found to outnumber the spermatogonial nuclei.

It has been reported by Herlant ('33) in *Lacerta muralis*, and Risley ('38) in the musk turtle, that when these animals are kept under laboratory conditions, they show active spermatogenesis in the winter. The fence lizards were kept in an environment very similar to the natural winter conditions, and they gave every indication of hibernating in the normal fashion. If the spermatogenic and spermiogenic activity observed in the fence lizard during the winter sleep is a part of the normal cycle, then it is suggested that darkness and low temperature do not inhibit testis activity in the fence lizard. Riley ('37) found that spermatogenic activity occurred in the house sparrow during a period of darkness, although he also found that the annual sexual cycle may be stimulated by light. Clausen and Poris ('37) discovered that the winter testis of *Anolis carolinensis* gave no indication of spermiogenesis. They were able to show that 6 hours of added illumination daily caused the seminiferous tubules to increase nearly twice their size and also stimulated the testis to such a degree that all the stages of spermatogenesis were produced, including numerous ripe spermatozoa. Apparently the inherent spermatogenic cycle may be influenced by an environmental factor such as light; therefore, it is not at all surprising to find an increase in the spermiogenic action upon emergence from hibernation, since the animals are then exposed to an increase in light, temperature, and an abundance of food.

In searching for factors controlling the testis cycle one ordinarily turns to the anterior hypophysis. Evans ('35a and '35b) has demonstrated that sheep pituitary extract and Antuitrin-S have a stimulating effect upon the reproductive system of *Anolis carolinensis*. The testis of *Eumeces laticeps*, according to Turner ('35), responded to injections of anterior pituitary-like substances from pregnancy urine during the season of lowest sexuality, by showing 148% increase in weight and the production of ripe spermatozoa. Mellish ('36) has subjected sexually inactive horned lizards, *Phyrnosoma cornutum*, to an increase in temperature and injections of hog pituitary extract, and found a stimulation of the testis comparable with that normally appearing in the breeding season. He suggests that the anterior pituitary may have an inherent cycle, and that the action of the testis may be the result of the anterior pituitary products being liberated and used at a time when environmental conditions are favorable. That the anterior hypophysis is

related to the reproductive cycle in the fence lizard has also been suggested by structural alterations that appear in the anterior lobe during the breeding season (Altland, '39).

It is of significance that no interstitial cells have been demonstrated in the testis of the fence lizard at any time throughout the year. No mention was made of interstitial cells in the testis of *Anolis carolinensis* by Evans and Clapp ('40) in their study of the effect of ovarian hormones and seasons on the testis. In all other members of the Lacertilia that have been studied thus far, interstitial cells have been described. In Lacerta, according to Herlant ('33) and Regamey ('35), the secondary sexual characters, such as the epididymis, the vas deferens, the sexual segment of the kidney, and the femoral organs, are at their maximal activity in May, at the time when the interstitial cells are best developed. In the horned toad, as reported by Blount ('29), interstitial cell development is closely correlated with the germinal cycle, the volume of interstitial material and the size of the individual cells being greatest during the breeding season. Turner ('35) mentions the presence of interstitial cells in the testis of *Eumeces laticeps*. Risley ('38) found interstitial cells with large rounded nuclei at all times during the year in the musk turtle, but he did not observe any seasonal fluctuations. Even though no interstitial cells were found in the fence lizard, the secondary sexual characters are very well developed during the breeding season.

SUMMARY AND CONCLUSIONS

Adult fence lizards were collected in the Duke Forest, Durham, North Carolina. The testes were preserved and weighed during every month of the year. A table showing the weights of the testes and size of the seminiferous tubules was constructed. An analysis of the testis weight and microscopic structure shows that spermatogenesis begins in August.

The testis is smallest in July, just before the onset of the reproductive cycle. Primary and secondary spermatocytes and spermatids gradually increase in number during a period of very active growth in September, October, and November. The testis reaches its maximum weight by November, at which time it is approximately 17 times as great as before the onset of spermatogenesis. There is a gradual transformation of spermatids to form spermatozoa during December, January, and February, and then in March and April spermiogenesis increases in intensity. The breeding season starts in May and continues for a period of approximately five weeks. Although maturation divisions are still prevalent in

July, the testis is undergoing degeneration, except for the spermatogonia which are actively dividing in preparation of the next cycle. Involution is completed by the end of July. From November until June there is a gradual decrease in the size of the testis, with the greatest reduction occurring after March. This reproductive cycle of the fence lizard is very similar to that described for lizards of the Genus Lacerta.

No interstitial cells have been demonstrated in the testis; in fact, at all times throughout the year there is very little intertubular space. The secondary sexual characteristics show seasonal alterations, with the maximum development during the breeding season.

DEPARTMENT OF BIOLOGY,
GETTYSBURG COLLEGE,
GETTYSBURG, PENNSYLVANIA

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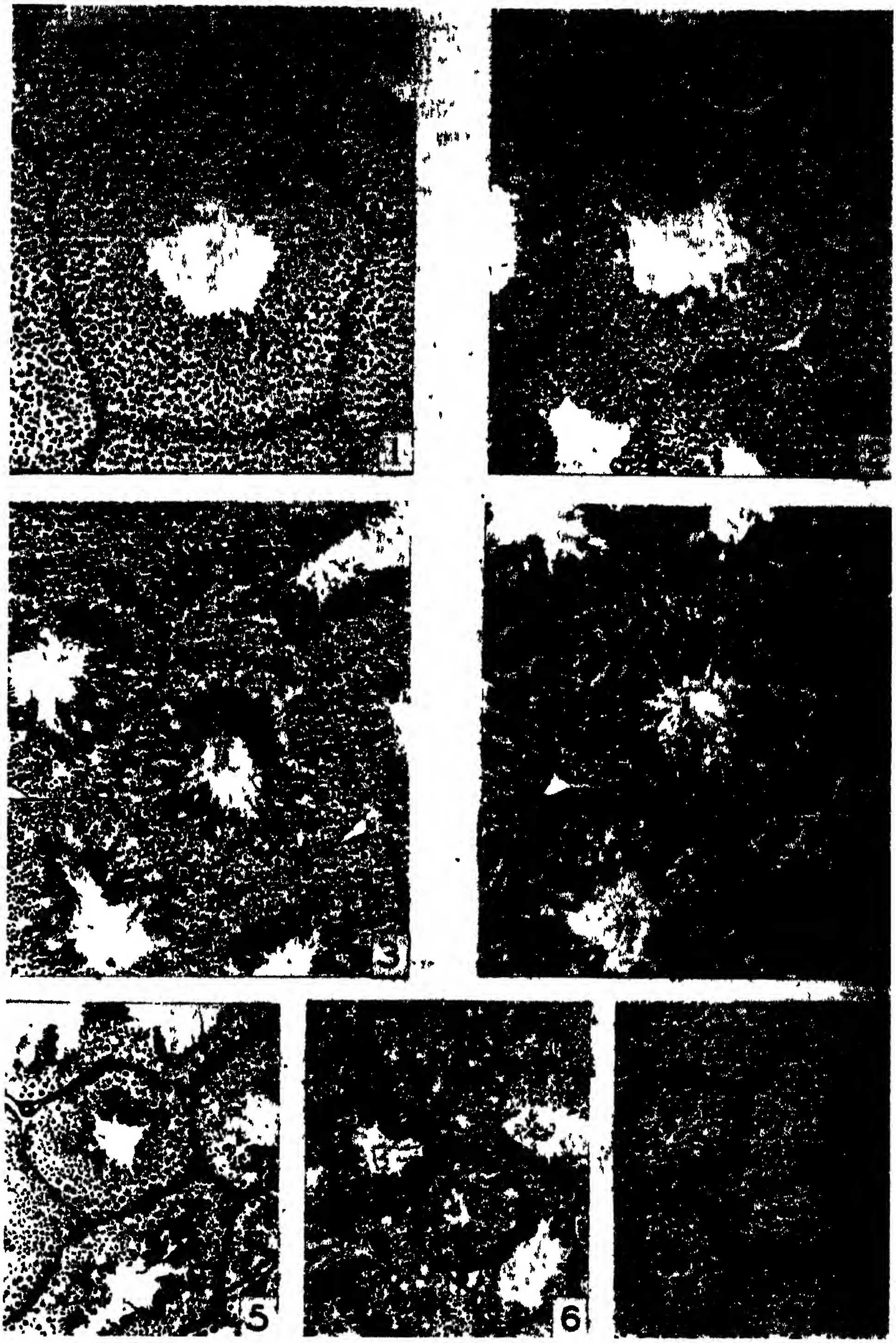
PLATE 2

EXPLANATION OF FIGURES

All figures were made from photomicrographs on Wratten M plates. A 16 mm. apochromatic objective, N.A.O. 30 and a compensating ocular 10 × were used. The magnification given represents the original magnification, which has been reduced one-third in reproduction. The photomicrographs were taken from material stained with iron hematoxylin and methyl green with the aid of a Wratten filter E22.

1. Section through the testis of a lizard preserved October 15th. Over half of the cells of the enlarged seminiferous tubule are primary spermatocytes in stages of division. Secondary spermatocytes and a few spermatids are also shown, but there are no spermatozoa present. There is very little intertubular space. × 200.
2. Transverse section of a portion of the testis preserved November 23rd. The secondary spermatocytes and spermatids are quite numerous, but mature spermatozoa are not found. Although this tubule is smaller than the one in figure 1, the average diameter is greater in November. × 200.
3. Section through the testis taken March 15. Spermatogenesis is clearly shown. Large numbers of mature spermatozoa have accumulated around the edge of the lumen. × 200.
4. Great masses of ripe spermatozoa are shown in the testis April 25th. It is difficult to observe the relationship the Sertoli cells have to such large quantities of spermatozoa. There are no interstitial cells present. × 200.
5. A portion of several tubules of a testis preserved June 10th. Spermatogenesis and spermiogenesis are still clearly shown. The connective tissue between the tubules is somewhat heavier than that shown in figure 4. The large Sertoli cells may be observed along the basement membrane. × 200.
6. Seminiferous tubules of a testis preserved July 10th. Although mature spermatozoa are still found, it is quite evident that there is a regression of the cellular elements. Along one tubule it is shown that the germinal contents have been reduced to a single layer of cells. Spermatogonial divisions are present. × 200.
7. Several seminiferous tubules of a testis taken August 4th. The involution of the seminiferous tubule has been completed. Spermatogonia are very numerous. It is apparent when a comparison of figures 1 through 7 is made that there is a marked change in the size and microscopic structure of the testis of the fence lizard. × 200.

PLATE 2



CRETINOID PROGENY FROM HYPERTHYROIDIZED RATS

By Bert Cunningham

One Text Figure

For a number of years, through experimentation in the zoölogical laboratories of Duke University, we have been aware of the fact that hyperthyroidization of pregnant rats produced cretinoid offspring. In experiments conducted as early as 1928 with the aid of Mr. W. A. Ellison and a year or two later with the aid of Miss Dorothy Schallert cretinoid young rats were produced. The variability of the results precluded publication at that time. In these early experiments a few of the normal offspring approached a lower weight comparable to that of experimental animals, while a few of the experimentals appeared to be nearly as heavy as normals. The average weight of experimental animals, however, was considerably below that of the normals. Later work has lead us to believe that these results were consistent and compatible with a reasonable theory.

In any effort to approach the study of the production of cretinism by experimental methods it is necessary to keep in mind that there may be two types of cretinism due to thyroid deficiency, namely, (1) that kind which is due to the genetic make up of the parents, and (2) that type which is due to the improper development of the thyroid gland due to causes other than genetic. In this study the interest centers around the second type.

It has been thought for a long time that animals with defective thyroids might pass on this condition to their descendants. Such conditions have been reported from time to time in the literature. Where such transmission occurs it may be assumed that it is genetic. On the other hand one would hardly expect that the removal of the thyroid from a normal female would affect the normal development of her offspring if after the operation she could and would breed. Apparently a number of workers have been unable to get progeny from thyroidectomized animals, but our experience on that question will be the basis of a later paper. Neither would one expect to change the course of nature in the embryos by hyperthyroidization of the mother.

The term cretin covers rather a wide scope since it ranges from "complete cretinism" to only a slight manifestation of the condition. There are a number of criteria which may be used in determining cretinism although it would be difficult to limit exactly the term or draw a distinct line between cretin and noncretin. In rats such factors as metabolic rate, heart rate, condition of coat, development of bones, and growth rate may be considered as criteria, as may also a histological study of the thyroid gland.

Through the kindness of Dr. M. O. Lee the basal metabolic rates (B. M. Rs.) of some of the rats from earlier experiments were determined. The rats selected were the most nearly normal in weight of our experimental animals, but their B.M.Rs. were consistently about 20% below

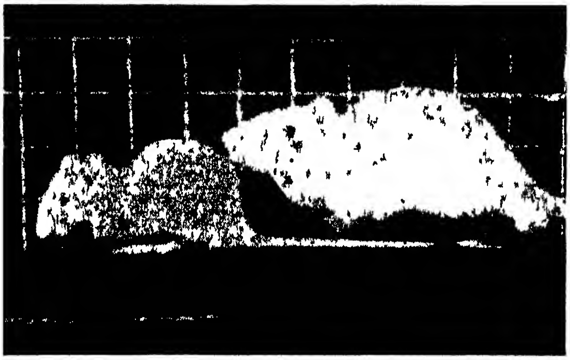


FIG. 1. (a) Photograph of a cretinoid rat. (b) Photograph of a normal rat Both 68 days old.

normal rats of similar weight from the same colony. Their heart rates were also lower.

Histological study of the thyroid involves the determination of follicular volumes as well as the volume of secretory cells. Such studies were made and the experimental animals showed a considerably reduced gross size of the thyroid, accompanied by a reduction of total follicular volume and total volume of secreting cells.

Three years ago with the aid of Mr. Fred Ketchum a rather large colony of experimental and control rats was set up, and the growth rates determined. Results concordant with earlier experiments were secured. For comparison purposes Figure 1 shows the largest cretinoid rat (a) and the largest normal rat (b) at 68 days.

The voluminous data of the earlier work are not incorporated in this paper as they are in agreement with the findings of our latest experi-

ments, the data of which are given here. The latter will serve as an example of the findings in the earlier work.

Since various experimental individuals have shown one or another of these criteria always associated with the reduced growth rate, and although no single individual has been examined for all the criteria, it is assumed that animals born of hyperthyroidized mothers which exhibit the retardation of growth are cretinoid in nature. It is also assumed that the degree of retardation of growth indicates somewhat the degree of the cretinoid condition. This is evidenced by the greater retardation of heart rate, and the lowered metabolic rate in the less rapidly growing animals among those from treated mothers.

It can be legitimately objected that the cretinism is not necessarily produced by hyperthyroidization of the mother. A critical test of

TABLE I

Average Weights of Normal and Cretinoid Rats Post natal to Weaning

	CONTROL				EXPERIMENTAL			
	No.	Av. Wt.	Max.	Min.	No.	Av. Wt.	Max.	Min.
Birth	42	5.78	6.7	4.8	65	5.03	6.2	4.2
7 days	42	11.5	15.0	7.5	63	10.2	13.1	6.2
14 days	42	17.6	25.0	12.1	61	15.8	22.0	10.5
21 days	39	26.4	38.0	20.8	49	22.0	28.0	16.5

whether or not the hyper condition of the mother has hampered the development of the foetal thyroid would lie in the growth rate response of the young experimental animals to thyroid medication.

With this test in mind the following experiments were carried out with the aid of Mrs. Sarah Harris.

Two female rats were mated to a male in each experiment. One of the females received daily doses of 10 mg. of desiccated thyroid tissue preceding and during pregnancy and through nursing. The other served as a control. The females were isolated at near term and the young weighed within 24 hours after birth. They were also weighed at 7, 14, 21, 30, 60, 90, and 120 days after birth.

At birth there was a little better than 10% difference in the average weight of the young. This differential was maintained until a few days before weaning but at weaning it had reached about 20%. The difference of maximum weights at weaning was about 30%. The complete data are shown in Table I.

Between 14 days and weaning (21 days) there was a very high death rate in the experimental group, for which no definite cause could be found.

At weaning the cretinoid animals were divided into two groups, one of which received 10 mg. of desiccated thyroid tissue per animal daily with its food, the other was untreated. The data are presented in Table II.

At 60 days the thyroid treated animals overtook the normals in weight and maintained this position past 120 days. The data in Table II include the 120 days weights but since the cretinoid group had been reduced by death to about half, those remaining at that time are not thought to be sufficient in number to consider as conclusive evidence.

TABLE II

Average Weights of Normal, Cretinoid, and Cretinoid plus Thyroid from Weaning to 120 Days

	NORMAL				CRETINOID				CRETINOID + THYROID			
	No.	Av. Wt.	Max.	Min.	No.	Av. Wt.	Max.	Min.	No.	Av. Wt.	Max.	Min.
21 days..........	39	26.4	38.0	20.8	27	21.5	27 0	16.8	22	22.7	30.5	16.5
30 days..........	36	39.6	55.0	30.0	21	29.2	39.5	21.0	17	30.3	44.10	22 0
45 days..........	34	74.9	105.0	44.0	21	60.0	85.0	29.0	16	63 4	89.0	41.0
60 days..........	34	105.6	143.0	63.0	21	93.5	135.0	49.0	15	105 4	146.0	82.0
90 days..........	28	167.3	214.0	122.0	20	143.5	170.0	111.0	15	170.0	239.0	131.0
120 days....	22	191.0	236.0	142.0	8*	176.0	218.0	148.0	7*	194.0	239.0	146.0

* The data for these are thought not to be significant.

From these data it is apparent that some cretinoid animals (based upon growth rate) occur in the normal stock. This is to be expected. It is also to be noted that among the experimental offspring there are some maximal growth rate animals that approach the normal. These latter can probably be accounted for by the variable response to medication of the treated animals and by the individual foetal response to the thyroid content of the maternal blood stream. Nevertheless when one considers the whole picture it is evident that the hyperthyroidized mother tends to produce cretinoid offspring by affecting in some manner the development of the foetal thyroid. That the effect is upon the thyroid is evidenced by histological study, basal metabolism studies and by the effect of replacement therapy, which seems to compensate completely for the defect.

Other studies* with Mr. G. W. Morrison on the learning ability of normal rats, of cretinoid rats, and cretinoid rats treated with thyroid add additional evidence to the conception that the young are really cretinoid but in variable degrees. These findings seem to agree rather well with the earlier observations of Gudernatsch (1915 and 1933) who by massive doses hyperthyroidized breeding rats. During extreme hyperthyroidization the rats failed to become pregnant. About three months after treatment ceased, the females became pregnant but later gave birth to abnormally small, short-lived young. Fortunately, the dosage used in the present experiments was large enough to be effective, but not large enough to be sterilizing. Gudernatsch used fresh bovine thyroid. Calculated in terms of the desiccated thyroid used in these experiments his dosage was about 2½ times as much as the daily dosage in these experiments. Schallert's data indicate that even at 10 mg. daily some animals become sterile. One rat that was pregnant when feeding was begun delivered a litter after 14 days feeding and then remained sterile for 118 days, at which time the experiment was discontinued. Another remained sterile for 165 days after which she produced a litter. The sterilizing effect was even more marked when both parents received thyroid. Fifteen females were mated to six males and both were given 10 mg. daily doses. With the exception of one pair all matings were sterile for periods varying from 62 to 138 days at which time the experiments were discontinued. One female gave birth to a litter on the 49th day, and another litter on the 112th. The 10 mg. dosage must be near the maximum at which fertility may be retained, especially after protracted treatment.

Schallert mated 13 females with 7 males and gave them 20 mg. desiccated thyroid daily. One animal was fertile at 11 days, and was removed from the experiment. Another, being pregnant when the experiment was started littered on the 16th day of feeding. She remained sterile thereafter to the close of the experiment. When the experiment was closed, ten of these mating had remained sterile for 61 days, one for 96, one for 97, and one for 112 days.

Apparently when Gudernatsch's animals reached a level of hyperthyroidization somewhat above that induced by 10 mg. daily doses they became pregnant and produced cretinoid offspring. Possibly a slightly higher dosage in these experiments would have given a higher incidence and a more pronounced cretinism in the offspring.

* In Press.

SUMMARY

Studies over a considerable period of time indicate that hyperthyroidized female rats tend to produce cretinoid offspring. The more recent experiments, involving 65 young from such mothers and 42 normal young, show that the growth rate of the former is significantly less than that of the latter. Earlier studies (not published) showed the cretinoid young to have a lower metabolic rate, and a slower heart rate. The offspring of hyperthyroidized mothers also showed a reduced gross size of the thyroid as well as reduced follicular volume and secreting cell volume. In the present series of experiments it was found that the cretinoid condition (so far as growth rate is concerned) can be overcome by thyroid medication which lends further support to the theory that the thyroid gland of the foetus has been affected by the hyperthyroid condition of the mother.

DUKE UNIVERSITY,
DURHAM, N. C.

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FAUNA OF PINE BARK

By Helen Ramsey

Bark of trees offers a satisfactory environment for a variety of animals. Some are characteristic of that habitat, others are present only accidentally. The crevices and tunnels in bark provide shelter for many. Food is available for both herbivorous and carnivorous species. Animals from the litter on forest floors often migrate up tree trunks to seek food or to avoid excessive moisture. An extreme example of this is that reported by Annadale (1907) in India, where earthworms migrate up tree trunks during periods of heavy rainfall and during the night when the humidity is high. Felt (1905–1906) in his report on insects associated with park and woodland trees mentions sawflies, cynipids, cecidiomyids, boring beetles, chrysomelids, curculionids, scotylids, lepidopters, aphids, and scale insects. Those that usually feed on pines were said to be bark-borers, ambrosia beetles, and leaf feeders.

Ecological surveys of wooded areas rarely take into consideration animals present in bark, as most of these are located deep in crevices or bore in the wood. Animals in the bark of fallen trees have been studied by Graham (1922), Adams (1915), and Savely (1939).. This fauna resembles that of litter more closely than that of the bark of standing trees, particularly after the first year that a log has lain on the ground.

This paper presents the results of a survey of the fauna inhabiting the bark of the loblolly pine, *Pinus taeda* Linn. and of the shortleaf pine, *Pinus echinata* Mill. Collections were made in the Duke Forest, Durham, North Carolina, during the summer of 1937 by Gladys Mitchell, and from February, 1939, to December, 1940, by the writer with the help of Dr. A. S. Pearse. Bark from a total of forty-nine trees in a variety of situations and at all seasons was examined. Samples consisting of square-foot areas were removed at each of three successive levels on the tree trunks; these levels were 3–15 inches, 15–27 inches, and 27–39 inches above the ground, respectively. Collections were rotated in such a way that the total areas from north, south, east, and west sides of the trees were equal. Each sample was collected and sorted on a large sheet and the animals from it preserved for identification. No attempt was made to collect specimens of microscopic size. Briscoe (1940) has

shown that such organisms may be abundant in bark. Furthermore, many Collembola and other minute animals were doubtless overlooked because of their small size or because they escaped before they could be captured.

A list of the species of animals found in pine bark is included at the end of this paper. In all 1479 specimens were collected, an average of 10.1 animals per square foot of bark. They represent both adult and immature stages of 137 identified species as follows: insects, 78; spiders, 48; centipedes, 6; phalangid, 1; snail, 1; and mites, 3; as well as several minute unidentified insects. Ants outnumbered other animals; large colonies were often found tunneling under the bark. Spiders also were always present; excluding ants more were collected than all insects combined. Many of the immature stages found represented species not regularly found in pine bark in the adult stage—stiletto flies, sawflies, ichneumon flies, grasshoppers, and lepidopters. There were also developmental stages of types commonly found in bark as adults; these included cockroaches, elaterids, etc.

Animals, particularly spiders, were most abundant in the bark of trees situated in regions of dense underbrush; other than this the situation seemed to have no bearing on the fauna of bark. Collections from various levels above the ground yielded somewhat different results (Table 1). In general the greatest number of animals was found near the base of a tree. The total number of specimens taken from the first square foot above the ground was 600; from the second, 457; and from the highest level, 422. Variations in respect to this distribution occurred among different species. Those animals which migrated up from the litter were naturally more abundant near the base of a tree; for example phalangids, snails, in some cases spiders, and particularly centipedes. Centipedes showed further specific differences among themselves; most were found near the ground, but Scolopendra was almost always at higher levels. At the other extreme were insects such as flies and wasps, which were apparently random visitors that had arrived by air and were usually found at higher levels on the tree trunk. The permanent residents such as ants, many beetles, mites, and most spiders were distributed rather uniformly over the areas examined. It is probable that collections from still higher levels would show fewer and fewer animals in bark; limited observations support this view.

Owing to the differences in the character of the bark of the two species of pine trees, it was expected that each might shelter a characteristic fauna. The bark of the loblolly pine is thick and contains deep crevices at right angles to the surface, whereas the bark of the shortleaf pine is

made up to a greater degree of a series of lamina. The species and numbers of animals collected from the two were surprisingly alike however. Seventeen loblolly and seventeen shortleaf pines similar in

TABLE 1

A comparison of bark faunas of 17 loblolly and 17 shortleaf pines

Figures indicate total number of specimens collected

	LOBLOLLY				SHORTLEAF			
	3–15 in.	15–27 in.	27–39 in.	Total	3–15 in.	15–27 in.	27–39 in.	Total
GASTROPODA	1	0	0	1	0	0	0	0
CHILOPODA	13	6	3	22	15	6	3	24
INSECTA								
Collembola	5	4	0	9	2	2	2	6
Thysanura	8	3	5	16	7	3	4	14
Coleoptera	3	11	6	20	5	10	10	25
(larvae)	1	0	1	2	0	3	0	3
Orthoptera	9	6	9	24	3	2	3	8
(egg-cases)	12	7	3	22	9	5	9	23
Neuroptera	0	0	0	0	0	1	0	1
(pupae)	2	1	0	3	1	0	0	1
Diptera	0	2	1	3	0	1	1	2
(pupae)	1	0	0	1	0	0	0	0
Hymenoptera[1]	204	76	127	407	49	10	153	212
(pupae[2])	2	5	1	8	10	3	2	15
Lepidoptera								
(larvae)	2	3	2	7	2	3	2	7
(pupae)	0	1	2	3	1	2	0	3
Heteroptera								
(nymph)	0	0	0	0	0	1	0	1
ARACHNIDA								
Acarida	1	0	0	1	3	3	4	10
Phalangida	5	4	2	11	3	1	1	5
Araneida	25	27	33	85	26	40	26	92
(cocoons)	6	4	4	14	9	2	4	15
TOTAL	300	160	199	659	145	98	224	467
TOTAL exclusive of ants	97	87	74	258	96	90	74	260

[1] Hymenoptera parasitic on cockroach eggs excluded.
[2] Larvae and pupae of ants excluded.

size and location are compared in Table 1. In a few species there was significant variation. Cockroaches, ants, and phalangids were much more abundant in loblolly pines. There were a few more spiders on shortleaf than on loblolly pines.

There was apparently no marked seasonal variation when average numbers of animals per tree per month were compared. Fluctuations in numbers appeared to be correlated somewhat with certain environmental factors however. There was a general increase in the number of animals in bark with a rise in temperature. This was noticeable in the course of a single morning; each successive collection yielded a higher count than the last. The largest collections were made around noon; the numbers decreased somewhat through the afternoon. Humidity showed only slight correlation with the number of animals collected, though in general high humidity was accompanied by a decrease in numbers.

Grateful acknowledgement is made to the following for identification of specimens in the groups indicated: Dr. A. M. Chickering, spiders; Dr. C. S. Brimley, insects; Dr. C. F. W. Muesebeck, Dr. C. T. Greene, Dr. A. B. Gurney, Dr. R. A. Cushman, and Dr. Carl Heinrich, insect larvae and pupae; Dr. H. B. Mills, Collembola; Miss Caroline Powell, ants; Dr. Henry van der Schalie, Mollusca; Dr. G. W. Wharton, mites; Dr. Mary E. Walker, phalangids; Dr. Nelle B. Causey and Dr. R. V. Chamberlin, centipedes. I am greatly indebted to Dr. A. S. Pearse under whose direction this work was carried out, and to Miss Gladys Mitchell, who furnished some of the data incorporated in this paper.

SUMMARY

1. In the Duke Forest 147 square feet of bark of loblolly and shortleaf pine trees was examined at all seasons, and 1479 animals were collected from it, an average of 10.1 per square foot. These included the following species: insects, 78; spiders, 48; centipedes, 6; snail, 1; phalangid, 1; and of mites, 3; a total of 137 identified species.

2. Little difference between the faunas of loblolly and shortleaf pines was found. Cockroaches, ants, and phalangids were more abundant on loblolly pines; spiders were somewhat more abundant on shortleaf pines.

3. The greatest number of animals was found in the lowest square foot examined, near the bases of tree trunks, and there were progressively fewer in the second and third square feet. There were specific variations in this respect however.

4. The abundance of animals in the bark was directly correlated with temperature, and was shown to vary with the time of day. It tended to vary inversely with the humidity.

ZOOLOGY DEPARTMENT,
DUKE UNIVERSITY,
DURHAM, N. C.

IDENTIFIED SPECIES OF ANIMALS COLLECTED FROM PINE BARK AT DURHAM, NORTH CAROLINA

	Number Collected
CHILOPODA	
Cryptops hyalinus Say	1
Geophylus rubens Say	75
Lithobius forficatus Leach	1
Lithobius sp.	3
Nampabium virginiensis Chamberlin	1
Scolopendra woodi Mein	9
GASTROPODA	
Zonitoides arboreus Say	1
INSECTA	
Collembola	
Entomobrya nivalis Linn.	14
Tomocerus flavescens Tull.	5
Thysanura	
Machilis variabilis Say	37
Orthoptera	
Gryllus sp. (nymph)	1
Melanoplus sp. (eggs)	2
Parcoblatta uhleriana Saussure	15
Parcoblatta (egg cases)	58
Coleoptera	
Alobates pennsylvanicus De G.	2
Aulonothroscus sp.	3
Baeocera speculifer Csy	4
Catogenus rufus Fab.	1
Chrysobothris floricola Gory	1
Elater verticinus Beauv.	1
Eros sp.	1
Helaps sp.	1
Lathridiidae	3
Lebia ornata Say	5
Lucidota atra Fab.	1
Melandryidae	1
Melanotus communis Gyll.	1
Melanotus fissilis Say	3
Melanotus sp. (larva)	1
Melyridae (larva)	1
Orthopleura sp. (larvae)	2
Paria canella quadrinotata Say	1
Platinus sp.	1
Platydema flavipes Fab.	1
Platydema sp.	1
Pterostichus adoxus Say	5
Ptilodactyla angustata Horn	1
Serica vespertina Gyll.	1
Spermophagos hoffmanseggi Gyll.	1
Tarpela micans Fab.	1
Tenebroides laticollis Horn	1
Tenebroides sp.	2
Tenebroides sp. (larva)	1
Zuphium sp.	1
Corrodentia	
Cinerea sp.	1
Psocus sp.	2
Timera sp.	1
Heteroptera	
Sinea sp.	1
Neuroptera	
Chrysopa rufilabris Burm.	1
Chrysopa sp. (cocoons)	2
Chrysopid cocoons	3
Diptera	
Psilocephala sp. (larva)	1
Sciara sp.	2
Hymenoptera	
Aphaenogaster texana carolinensis Tryon	1
Amblyteles sp.	1
Apanteles sp. (cocoon)	1
Bezzia setulosa Loew	4
Braconidae (cocoons)	2
Camponotus caryae Fitch	187
Camponotus castaneus americanus Mayr	182
Camponotus herculeanus pennsylvanicus De G.	14
Camponotus herculeanus pennsylvanicus ferrugineus Fab.	3
Chalcidae	2
Crematogaster ashmeidi Mayr	63
Crematogaster lineolata Say	17

	Number Collected
INSECTA	
Hymenoptera	
Leptothorax curvispinosus Mayr	194
Myrmecina gramnicola americana Em.	1
Neodiprion sp. (cocoons)	13
Paniscus sp. (cocoons)	3
Pogonomyrmex badius Latr.	2
Prenolepis imparis testacea Em.	4
Solenopsis molesta Say	165
Solenopsis pergandei Forel	3
Syntomosphyrum sp. (parasitic on Parcoblatta egg cases)	33
Tetrastichus sp. (parasitic on Parcoblatta egg cases)	7
Vespula maculifrons Buy.	1
Isoptera	
Reculitermes flavipes Koll.	50
Hemiptera	
Metapterus annulipes Stal. (nymph)	1
Homoptera	
Fulgoridae (nymph)	1
Lepidoptera	
Blastobasidae (larvae)	7
Geometridae (larva)	1
Geometridae (pupae)	2
Malacosoma americana Fab. (larva)	1
Olethreutidae (*Eucosma?*) (larvae)	4
Phycitidae (larva)	1
Psychidae (larva)	1
Solenobia walshella Clem. (cocoons)	5
ARACHNIDA	
Acarida	
Allotrombium pulvinus Ew.	11
Erythraeus sp.	1
Phalangida	
Leiobunum sp.	16
Araneida	
Agelena naevia Walck.	3
Agelena sp.	12
Aranea corticaria Em.	1
Aranea sp.	2
Ariadne bicolor (Hentz)	9
Anyphaena sp.	1
Bathyphantes sp.	6
Ceraticelus fissiceps (Cambridge)	1
Ceraticelus sp.	1
Ceratinopsis interpres (Cambridge)	2
Cicurina sp.	1
Clubiona pallens Hentz	32
Clubiona riparia Koch	1
Coriarachne versicolor Keys.	11
Dictyna sp.	2
Dipoena nigra (Em.)	3
Drassus neglectus Keys.	1
Drassylus sp.	3
Epeira sp.	2
Erigonidae	3
Ero furcata Villiers	1
Herpyllus sp.	3
Lepthyphantes nebulosa Sund.	1
Leucauge venusta (Walck.)	1
Linyphia lineata (Linn.)	3
Linyphia insignis Blackwell.	1
Lithyphantes sp.	1
Lycosa scutulata Hentz	1
Lyssomanes viridis Hentz	1
Marpissa undata (De G.)	16
Micrathena gracilis (Walck.)	1
Mimetus interfector Hentz	3
Mimetus syllepsicus Hentz	1
Oxyopes salticus Hentz	1
Oxyptila sp.	1
Pardosa sp.	1
Phidippus audax Hentz	2
Philodromus sp.	8
Robertus riparius (Keys.)	1
Salticus scenicus (Clerck)	4
Scytodes thoracica Latr.	1
Steatoda borealis Hentz	1
Theridion porteri Banks	2
Theridion tepidariorum Koch	2
Theridion sp.	30
Ulesanis americana Em.	1
Xysticus ferox Hentz	2
Zelotes sp.	1

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LETTERS FROM THE COLLECTION OF DR. CHARLES WILKINS SHORT

Edited by W. C. Coker

Through the generosity of the family of Dr. C. W. Short, The University of North Carolina has acquired all of the letters left in his collection after his death. We have gone over these letters and selected those we think will prove of some interest not only to botanists but to others of our readers. Most of them are to Dr. Short himself from prominent American botanists of the period. The greater number are from Dr. Asa Gray, and these, we feel sure, will be a welcome supplement to the series of his letters in two volumes edited by his wife (Riverside Press, 1894). Our thanks are due to Dr. J. G. deR. Hamilton and Mrs. Lyman Cotten, of the Southern Historical Collection in the University of North Carolina, for their courteous assistance in making these letters available.

We have with few exceptions arranged all the letters in chronological order, as the contents are not rarely consecutive in subject matter although from different correspondents. The letters are printed just as written except for omission of parts of two or three letters as indicated and for correction of a few obvious misspellings, punctuation, and some obscure abbreviations. Brief footnotes are added for information when individuals not widely known are mentioned in the letters.

In addition to these letters, The University has also been given Dr. Short's herbarium work table, which has been placed in our herbarium here, as an interesting museum piece.

Dr. Short was born in Woodford County, Kentucky, Oct. 6, 1794. He studied medicine at the University of Pennsylvania and was given the M. D. degree there in 1815. He became Professor of Materia Medica and Medical Botany in Transylvania University, Lexington, Ky., in 1825, and went to the University of Louisville as professor of the same subject in 1838. He retired to his home, "Hayfield," near Louisville in 1849 and died there on March 7, 1863.

During his entire mature life Dr. Short was intensely interested in

botany and corresponded with most of the prominent American and many European botanists of his time. Among his contemporaries Short was highly regarded as a careful, exact worker, and most painstaking in the selection and preparation of his plant specimens. The herbarium he acquired was a large one, and as Dr. Gray has said "is a model of taste and neatness." For an appreciation of this herbarium, given to the Philadelphia Academy of Natural Sciences after his death, see letter of Elias Durand to William Short, dated Feb. 24, 1864. Many of Dr. Short's duplicate specimens are to be found in the National Herbarium, Gray Herbarium, New York Botanical Garden, Missouri Botanical Garden, Kew, and over 400 at the British Museum of Natural History.

Dr. Short was a man of considerable means and was regarded, as these letters will show, as a prominent patron of the science of botany. The rare and beautiful flowering perennial *Shortia* of our Carolina mountains, famous for its history, found by Michaux and lost to botany for about seventy-five years, was named by Asa Gray for Dr. Short (see Garden and Forest **1**: 506, 1888; Amer. Bot. **32**: 66, 1926, etc.). This plant is frequently referred to in these letters (see especially the last one in this collection). There were also a number of species named for Dr. Short, several of which are listed in the letter just mentioned.

Dr. Short wrote no extensive works on botany but did contribute important papers on botany and biography. Most of these occur in the Transylvania Journal of Medicine. His "Catalogue of the Native Phanogamous Plants and Ferns of Kentucky" (with Robert Peter and Henry A. Griswold) appears in that Journal in 1833; his "Introductory Address to a course of Lectures on Materia Medica" in the same volume; and his "Biographical Memoir of H. Hulbert Eaton, A. M.," in the volume for 1832. For other items, see the list in the Catalogue of the Library of the Arnold Arboretum of Harvard University, Volume 1. For further biographical notes on Dr. Short, see the following:

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[*C. W. Short to William Short*]

Lexington, September 11th, 1838.

My dear Uncle,

Shortly after I had last the pleasure of addressing you, I went to Louisville, and spent there several days in the business of house-hunting. Having at length completed that matter for the present, by renting one for a year, I returned to Lexington a few days past; and, as I was on the point of writing to you again, I am favoured this morning with your letter of the 4th inst. and as I know not that I shall have soon a more convenient season to acknowledge it than the present moment, I lose no time in doing so.

I am gratified that the temporary arrangement I have made in Louisville concurs with your views; and I esteem myself fortunate that I have at length been able to secure in this way so comfortable a residence as I have. It is one among the best houses in the place, and one which I had before endeavored to rent, but the proprietor, wishing to sell it, had refused to rent; and only did so at last, in consequence of being unable to get his price. So that for one year, I hope, we shall be comfortably settled; and in that time, I trust, an opportunity may offer for a more permanent location on advantageous terms. There is certainly now no scarcity of houses for sale in that place; but the prices of all seem to me high, and but few of them meet my views in regard to locality, size, convenience, etc. It is certainly a matter of importance in so large a place, and where, of course, there are so many medical men, that the residence of a physician should be permanent and fixed; for a removal from one quarter, to a distant point of the same town, is almost as bad as an entire change of residence. This inconvenience I shall, therefore, endeavour to obviate as soon as I can. In regard to a sale of my Lexington property, I fully appreciate your advice, which I am glad to find concurs also with that of all my friends here, as well as my own opinion. .... As soon as this matter is disposed of, I shall be prepared to take up the line of march to our new home, where I trust we shall be established by the 1st of October, or very soon thereafter.

The Building, in progress for the Medical Institute of Louisville,

comes on admirably, and no doubt is entertained of its completion in time for the coming session. It is an admirable structure—equal to anything of the kind in the Union, and very far superior to any in the West. The purchases made in Europe during the summer of books, apparatus, etc. etc. are arriving: confident anticipations of success inspire the bosoms of all my colleagues; the citizens of Louisville continue to manifest the deepest interest in the issue: we have received from individuals in various portions of the western country, assurance of hearty cooperation; so that I trust we shall be, in a few months, "on the fully tide of successful operation."

You are pleased, my dear Uncle, to inquire the title of the British publications to which I referred, as containing a mention of myself. They are *Curtiss' Botanical Magazine;* in the last six or eight volumes of which frequent reference is made to me, especially under the heads of "Hydrastis Canadensis," "Silene Virginica," "Bellis integrifolia," etc. etc. The *Flora Boreali-Americana*, by Sir W. J. Hooker, 2nd vol. under the head of "Aster Shortii," and elsewhere. The *Journal of Botany*, by the same author, under the head of "Drummond's* collections in N. America," "Cyamus luteus" etc.—*Icones Plantarum*, by the same, article "Draba dentata."—*Companion to the Botanical Magazine*, under the mention of "Podostemum ceratophyllum," and other places of the same work.—These are a few references to these foreign works, which I now recollect—I could mention many others, but that my library being packed up, I am unable to have access to it. All the recent publications on this Science in our own country give me ample credit for my contributions; as *Gray's Elements of Botany—Torrey & Gray's Flora of N. America—Darlington's Flora of Chester County (Pa.)—Eaton's Manual of Botany*, 7th Edition: besides various papers by different writers in *Silliman's Journal, Journal of the Academy of Natural Science of Philadelphia, Annals of The Lyceum of Natural History of New York*, etc. etc.—With this dry detail of references I must close this letter, only adding an expression of the sincere attachment and affection with which I am, my dear Uncle, yours very truly

C. W. Short

* Thomas Drummond (1780–1835), a Scotch nurseryman and later curator of the Belfast Botanic Garden, who came to America in 1825 as assistant naturalist to the second Overland Arctic Expedition. He travelled in northern and northwestern United States and later in western Texas. In 1835 he came to Apalachicola, intending to explore all the Florida peninsula, but on a trip to Havana, Cuba, suddenly died there in that same year. The familiar Drummond phlox of gardens was found by him in Texas.

[*Thomas Nuttall to C. W. Short*]

Rainhill near Prescot, Lancashire.
Jany, 24th 1849

Professor Short,
Dear Friend,

I have not now had the pleasure of hearing from you for a very considerable time but I hope you are in the enjoyment of your usual good health and spirits.

I have not been lately doing much in Nat. History, more than amusing myself in the cultivation of plants in which I yet take my usual interest. Minerals have somewhat occupied my attention of late; tho' last winter I paid a visit to Philadelphia and New York and sailed from Boston by the steamer. While in Philadelphia I undertook to describe and publish a century of plants selected from a set collected for me in the Rocky Mts. and Upper California: these have appeared in the Journal of the Academy of Nat'l Sciences, and I have received some copies in England.

If this spring you could collect for me a few seeds of my old favorite *Collinsia verna*, which has never yet been seen in England, the *Synandra**[,] *Dracocephalum cordatum*, I should be exceedingly pleased to see them growing in my garden as a reminiscence of past times so pleasing when yet young and healthy I saw them first growing in my favorite *land of the West!*

Erigenia will be in flower when this scrawl reaches you. Of this I think you once sent seeds but they did not grow, the bulbs probably would. These things sent to our friend George W. Carpenter, Druggist, Market Street, Philadelphia, will be directly transmitted by him to me as soon as they arrive. May I beg of you in your great kindness to excuse this begging and tasking you, when you bear in mind that if I am ever to see those things it must either be by you or not at all.

In return is there any thing I can do for you on this side the Atlantic, if so let me know and I will attend to it at once.

Your obliged friend and servant
Thos. Nuttall

* Nuttall's genus *Synandra* still holds, but his species has been superseded by the earlier name, *hispidula*, of Michaux. His plant is now known as *Synandra hispidula* (Michx.) Britton. *Dracocephalum cordatum* is now known in this country as *Meehania cordata* (Nutt.) Brit.

[*Thomas Nuttall to C. W. Short*]

Sutton near Prescott, March 13th, 1850

Dear Friend,

It is now a long time since I had the pleasure of hearing from you but hope you are in the enjoyment of good health as I am at the present.

I have since my visit to the U. S. in 1847 done nothing in botany or in any other department of Nat. History except the effort of adding to my cabinet of minerals. I still take great delight in the cultivation of my garden, and always rejoice to see with the return of the seasons some "old favorite faces" in the plants of America which grow in my garden, and which are always amongst the favorites of my collection.

Strange to say, I have never yet been able in any way to obtain the seeds of my great spring favorite *Collinsia verna*, which tho' the first known and the most common has never yet reached England.

Will this note reach you in sufficient time to collect and send me a few seeds by letter to our friend G. W. Carpenter, Druggist, Market Street, who will transfer the same to me.

You once sent me seeds of *Erigenia* but they would not vegetate. *Sinandra* [*Synandra*] too has never been seen yet in England.

I am presuming to impose on you a tax, but I think nothing whatever of the plant kind would please me more than *one sight* more at my early favorites. You will therefore I make no doubt excuse the strong desire I feel before I die to see those plants again.

[Signature cut out but certainly from Thomas Nuttall]

[*Thos. Nuttall to C. W. Short*]

Rainhill near Prescot
Lancashire, Jany. 26, 1854.

Dear Friend

You can scarcely conceive how much I was delighted to receive from you the packet of seeds of *Collinsia verna*. I planted them as you directed but not one germinated—their vitality was gone in some way I cannot account for but may I beg of you still to take the trouble of once more collecting some for me in the coming season when perhaps I may be more successful. Send a few in a small packet by post and I shall probably receive them in safety.

We have had a visit from Mr. Lea* of Philadelphia whom you know as a conchologist.

Our winter here has been as cold as any in Pennsylvania tho' now nearly over for the present. I enjoy good health as yet and hope you do the same tho' we are both far descended into the vale of years.

[Signature cut out but undoubtedly from Thomas Nuttall]

* Isaac Lea (1792–1886), born in Wilmington, Del. When he was fifteen years old he moved to Philadelphia, where he was later for many years engaged in publishing and bookselling. He wrote on mineralogy, fossils, geology, etc., and was an authority on fresh-water mussels.

[*Asa Gray to C. W. Short*]

Cambridge, March 28th, '49.

My dear Doctor,

The first package of Gregg's* plants, which you forwarded to me so long ago, by some mischance fell into the hands of a Professor *Alonzo* Gray, Brooklyn, N. Y., who seems to have detained them a long time, so that they only reached me when my Plantae Fendlerianae† was nearly through the press; as you will see by a note near the last part, in a copy which I forwarded to you some time since, and which I hope you duly received.

Your second package came in good season to Dr. Torrey, who kindly divided it with me. There were many good and interesting things in these collections, as well as in those of Wislizenus‡ from the same regions. And I have lately sent a collector, Mr. Charles Wright,§ to go across from Texas into those regions, south of Santa Fé, to see if more cannot be gathered from those new interesting countries.

The rest of Plant. Fendl. will be coming out, I hope, before a great while; but I am at present busy on the 2nd volume of Genera, which will be published before long, and which I hope you may be pleased with.

I am exceedingly driven with work, or I should have written long before this; but letters unanswered are apt to accumulate in enormous piles, while I am engrossed with more pressing things. But, believe me, I shall always be glad to hear from you.

With best regards,

I remain yours truly,

Asa Gray

* Josiah Gregg (1806–1850), Santa Fé trader and author, born in Overton County, Tenn. He published *Commerce of the Prairies* in 1844. He travelled

extensively through the southwest, including parts of Mexico and was a keen scientific observer. A number of plant species have been named for Gregg.

† August Fendler (1813–1883) was born in Prussia and came to Baltimore, Md., in 1836. He worked at various occupations, and wandered over many parts of the central and western United States, Isthmus of Panama, Venezuela, collecting plants for various herbaria. He died on the Island of Trinidad.

‡ Friedrich Adolph Wislizenus (1810–1889), German physician who came to this country in 1835, settling first in New York. He later lived and travelled widely in the west and in Mexico, collecting many plants. These were described by Engelmann in his *Sketch of the Botany of Dr. A. Wislizenus's Expedition* (Washington, 1848), and included many new species as well as the new genus *Wislizenia*, named for the discoverer. He spent the latter part of his life in St. Louis.

§ Charles Wright (1811–1885), botanist and collector of plants, born in Wethersfield, Conn., where he also passed the later years of his life. In 1837 he went to Texas and spent two or three years botanizing there, while supporting himself by surveying and teaching at various places. Later he extended his explorations farther south and west along the Mexican frontier and made a collection which forms the basis of *Plantae Wrightianae*, published in the Smithsonian Contributions to Knowledge. Wright went on a tour around the world with the North Pacific Exploring Expedition under Captain Ringgold, leaving Norfolk, Va., in 1853. In the fall of 1856 he began his long exploration of the botany of Cuba, which resulted in many rich collections. These were published by various botanists, mainly Prof. Grisebach of Göttingen, Amos Eaton, Berkeley and Curtis, Sullivant, and Tuckerman.

[*Wm. Darlington to C. W. Short**]

West-Chester, Penna., Sept. 12, 1849.

My dear Sir,

Much of my leisure time, for the last two years, having been occupied with compiling and transcribing the *correspondence*, alluded to in the annexed *Prospectus*,—and in revising the *Proof sheets*, for the Publishers, —I thought I would send you the *Prospectus*, to apprize you of what was going on: believing it to be a subject in which you would feel some interest. I do not, however, send the Prospectus with any interested motive, in the way of *subscriptions*—but merely for your information: for I have no interest whatever in the publication. I made *a present* of the ms. to the Publishers, on condition they would issue it in decent style;—which they have done. It is now all printed, and makes a handsome 8vo Volume of 585 pages. I presume the publishers will send a few copies to the West. If you should get hold of it, I should be gratified to hear how you like it. I have such a passion for *antiquities* of that

description, that I may be deceived in my estimate of these; but I think you would be amused, and interested, in the perusal.

Very sincerely, Dear Sir, your old friend,

Wm. Darlington

Prof. C. W. Short,
Louisville, Kentucky.

* This letter was written on the inside of a folder which presented: "Proposals for Publishing by Subscription, Memorials of John Bartram and Humphry Marshall, The Eminent Pennsylvania Horticulturists, Botanists and Naturalists, with Occasional Notes and Biographical Sketches, by William Darlington, M. D."

[*W. H. Harvey* to C. W. Short*]

Charleston, S. C.
March 12, 1850.

Dear Sir

When I saw you last winter in Philadelphia I fully expected to have had the pleasure of calling on you at Louisville, but I have not been able to make out time for the Great Valley—I must now defer visiting the western country until my next tour in America, whenever that may be. I have been spending the last month on the Florida Keys where I went for the purpose of exploring the marine vegetation, and I had originally intended going on from Key West to New Orleans up the River—but found that I could not do so without sacrificing the object which led me to Key West. So, with great reluctance, I have been compelled to retrace my steps homewards.

You mentioned, when I had the pleasure of seeing you, that you had a considerable mass of duplicates of Kentucky plants and kindly offered to put up a set for our Dublin Herbarium. Should you have had leisure to select them since your return home I shall be very glad to receive them. If there be an Express from Louisville to Washington, D. C., they might be addressed there: Prof. Harvey, care of Prof. Henry†, Smithsonian Institute, Washington, D. C., or if you could equally well send them to New York, my address there is:—Prof. Harvey, care of Messrs. Abm. Bell & Son, 117 Fulton Street, New York. Messrs. Bell & Co. correspond with Mr. Saml. Nicholson, Merchant, New Orleans, who would doubtless take charge of any parcel addressed to their care, if sent to him—but I have personally no acquaintance with Mr. Nicholson. It would therefore be well, should you send via New Orleans, to ask Mr. N. to forward at once to Messrs. Bell.

I purpose returning to Europe by the first steamer in May—but if the parcel did not arrive in time to go with me, Mr. Bell would take care to forward it.

I shall be very glad to hear from you, and to reciprocate your botanical favours in any way in my power that may be most agreeable to you. I have still remaining undistributed a few Californian plants collected by my predecessor Dr. Coulter,‡ which I shall be glad to send you—and if you care for South African plants I could also send you a collection. I have also generally by me a considerable number of duplicate marine Algae, should you feel an interest in such things.

Believe me, Dear Sir
very truly yours
W. H. Harvey
of Trinity College
Dublin

I leave Charleston for Washington, D. C., in a few days, and remain with Prof. Henry for about a fortnight.

* William Henry Harvey (1811–1866), botanist, born near Limerick, Ireland. He was professor of botany in Trinity College, Dublin. He travelled in eastern America in 1849–50, and published his *Nereis Boreali-Americana, or Contributions to a History of the Marine Algae of North America*, 1852–1858, in three parts in the Smithsonian Contributions to Knowledge.

† Joseph Henry (1797–1878), a physicist, born in Albany, N. Y. From 1832–1846 he was professor of Natural Philosophy at Princeton. In 1846 he became the first secretary and director of the Smithsonian Institution and remained there for the rest of his life. He independently discovered the induced current but did not publish his findings. Faraday published his own discovery in 1831.

‡ Thomas Coulter, predecessor of W. H. Harvey as keeper of the herbarium of Trinity College, Dublin. He died in 1843.

[*W. H. Harvey to C. W. Short*]

Washington—March 27—1850.

My dear Sir:

I have received your very kind letter of the 19th informing me that you had sent me a parcel of plants to the care of Mr. Carey, New York. Mr. Carey is an old friend and correspondent of mine, and will take excellent care of the parcel till I claim it from him.

I shall not fail, on my return to Europe, to prepare a parcel for you

and shall put in it as many of Coulter's plants as still remain undistributed.

Believe me, Dear Sir
Very sincerely yours,
W. H. Harvey

[*Asa Gray to C. W. Short*]

Cambridge, March 21st, 1850.

My dear Sir,

I had the pleasure to receive today your letter of March 13th. and will immediately reply to its points.

Harvey will be in New York in time to return to Europe early in May, and Carey* will give him your parcel as I may not see him. I will instruct him about Reichenbach which must also go from New York and Dr. Hietz' with it.

I shall be happy if I can serve you in any way.

The printing of Plantae Lindheimerianae† has gone on very slowly; I will send the sheets as soon as done up to Compositae.

I immediately wrote to Putnam, New York, to send you two copies of Genera Illustrata through Morton and Griswold; perhaps he has scarcely had the opportunity yet.

Wright's plants will not be very numerous I find, not more than 4 or 500 species after the very first sets, and not more than 12 sets in all. But they are extremely good plants and with considerable novelty. I can have a set for you as soon as distributed, notify you of the number and amount, and you can remit to Sullivant the money; for I shall ask him to look after Wright's pecuniary affairs a little while I am away.

I will look after Shortia in Paris. I am mortified that it has not been found yet.

The plant you raised from seeds is Hymenoxys californica, Torr. (Ptilomeris, Nutt.).

I wish I could get through the Flora!

We hope to be off early in June. I am how hard pressed with 3rd Edition of Bot. Text Book, the first part of which I have rewritten and enlarged making it a small 8vo. It has cost much time and labor, and put back other things sadly.

I remain with much regard,
Yours faithfully,
Asa Gray

* John Carey, an Englishman who spent the years 1830–1852 in the United

States and devoted most of this time to botanical work, especially assisting Asa Gray in the preparation of his publications.

† Ferdinand Jacob Lindheimer (1801–1879), a German who lived in Texas and collected plants there for over thirty years. *Plantae Lindheimerianae*, published by Engelmann and Gray in Journ. Boston Soc. Nat. Hist. **5**: 210–264, 1845; **6**: 141–240, 1850, was based on his findings and contains many new species. The genus *Lindheimera* was named for him.

[*Geo. Gilliss to C. W. Short—April 12, 1850.*]

With my compliments please receive a few strawberry seeds sent me from "Santiago, de Chiele"—by my son Lt. Jas. M. Gilliss of the U. States Navy—in a letter dated 30 Dec. 1849. He says "We have now in season, oranges, cherries, strawberries, plums, pears, figes, water-mellons, green corn, etc.—: strawberries most extrordinary in size, many being as large as the Guinea fowls' eggs. I send you some seed."

Yours truly
Geo. Gilliss
Louisville, Ky.,
Apl. 12, 1850.

Note—The above strawberry seed were properly committed to the ground in the spring of 1850, but there after care being confided to a stupid Dutch cabbage gardener, they were *of course*, neglected and lost.

C. W. S.—
Aug.—1850

[*John Torrey to C. W. Short*]

Princeton, N. J.,
Aug. 24, 1850.

My dear Sir,

I was greatly pained to learn the sad cause of your sudden return to Kentucky. You have again been stricken sorely and I pray you may be sustained by Him who acts wisely and benevolently even in the afflictions which He brings upon us.

Much did I expect to enjoy in our purposed excursion. It was not till a week after the time I was to meet you in Philadelphia that I heard of your return home. I informed Dr. Darlington of our intention, and he expresses much sympathy for your loss. If I can get away next month I shall make him a visit by myself.

The scientific meeting at New Haven is well attended; and I suppose you read the proceedings in the newspapers. I spent three days there

this week, but was obliged to leave, as my duties in the college required my presence here. There is some prospect of the next meeting being held in Cincinnati, and if the Association should conclude to go there, I shall hope to see you *in situ* (D.V.*) next year.

Are you a subscriber to Mr. Wright's Texan and New Mexico expedition? Several gentlemen made up a purse for him, but the poor fellow is getting quite low in funds, and I, for one am unable to do any more for him. Dr. Gray is in Europe and could hardly keep up regular correspondence with him. It was from Dr. Gray that Mr. W. received all his remittances. I thought from a remark which you made when I had the pleasure of seeing you in Princeton, that you might be willing to lend some aid to Wright, and receive a share of his collections. He is probably at this time exploring the northern part of Texas, but any thing for him can be directed thus:

Mr. Charles Wright
San Marcos, Hays Co.
Texas.

Mr. Wright's previous collections are in Dr. Gray's hands, save what may be distributed among the subscribers. You will soon be able to judge of their value, by a list of them which Dr. Gray will publish. He is to send his notes from England.

With high. regard,
I remain yours,
John Torrey.

Prof. Short.

* *Deo volente.*

[*S. B. Buckley* to C. W. Short*]

Starkey, Yates Co., N. Y., Sep. 2. 1850.

Dear Sir

Dr. Torrey told me a few days since that you have become possessed of a large fortune, part of which you were anxious to expend in advancing the Science of Botany. The region around Salt Lake is almost entirely unexplored. I should like to start next spring and remain a year with the Mormons and then proceed to California and explore that and then return home and publish whatever I obtain new. If you will furnish the means I will perform the labor of collecting—furnish you with a suite of the botanical specimens collected and we will jointly publish whatever is new. If this proposal does not suit you I shall probably undertake the business at any rate next spring. I think there is a great chance for discovery, no botanist having visited the region excepting

Fremont and he only passed through and afterwards lost part of his collection. Let me hear from you soon and direct to this place.

Yours truly
S. B. Buckley

* Samuel Botsford Buckley (1809–1884), native of New York state, a naturalist of broad interests who travelled extensively in the south collecting plants, fossils, shells, insects, etc. The remarkable and rare shrub *Buckleya* of the southern Alleghanies was named for him. The latter part of his life was spent in Texas, where he was at two different periods state geologist. Among his discoveries was that of a skeleton of *Zeuglodon* 70 feet long in Clarke County, Alabama, in 1841. See the next letter.

[*John Torrey to C. W. Short*]

Princeton, Sept. 21st, 1850.

My dear Sir—

Your letter of Sept 11th, inclosing a check for one hundred dollars, reached me two days ago, but I have been so closely occupied in delivering some extra lectures (in the absence of a brother professor) that I could not well acknowledge your favor before. You have been extremely liberal to Mr. Wright, and in thus aiding him have done much for North American Botany. Although I do not think you have contributed so handsome a sum to get an equivalent in dried plants, I have no doubt Mr. Wright will send you sets of his choicest specimens. I shall take means to get your contribution in his hands.

I am well acquainted with Mr. S. B. Buckley. He has corresponded with me on botanical matters for eight or ten years. He has explored in Illinois and other western states. For several years he resided in Alabama, where he collected largely. He has also explored the mountains of Tennessee, the Carolinas, Georgia, and Virginia. Afterwards he collected in Florida. I believe him to be an honest man, as he is certainly a zealous collector. He needs a little training as to the quality of his specimens—but I think he would engage, if sent on another expedition, to collect specimens that would be unobjectionable. For several years past he has not attended much to Botany—but his zeal for the science seems unabated. When I saw him lately at the Scientific Meeting in New Haven, he expressed a strong desire to visit the Rocky Mountains in some far western region, and I mentioned to him that the neighborhood of the Salt Lake would offer a good harvest of interestl ing plants. I happened to be talking about you—and of your liberaoffer to contribute towards botanical surveys, but don't think that I encouraged him to hope any thing from you. When he went on the

Florida expedition, his means were quite limited, and he was badly provided for making collections. Hence his specimens were poor. In making up his sets, too, he made them rather scanty, but on all other occasions he has been (at least to me) quite liberal. I really think he would do very well to explore the far west. He is quite trustworthy, has had much experience in collecting, and is pretty well acquainted with North American Botany. If I could afford it, I would without hesitation aid in his outfit—but I can, at present, do very little in this way.

As to those fossil bones—Buckley collected them with great labor, and considerable expense. He was desirous of disposing of them to some public institution for a fair sum—and even offered them to a society in England—but was finally obliged to dispose of them for a hundred dollars or so to Dr. Emmons of Albany. When I last saw them they were in the New York State Geological Rooms.

I am sorry on many accounts that Dr. Gross has concluded to leave the Medical Institution of your city—although I believe he will be a valuable accession to the profession in New York. We have reason to believe that he will not find the income of his new chair equal to what it has been represented to be. I doubt not he is a better teacher than Dr. Mott—Although, his name is not yet so great. It is natural enough that I should not be glad to have a man of Dr. Gross' talent in the opposition school—but you may be sure he will be well received by all my colleagues, by whom he is well known and greatly respected. I shall be glad to make his acquaintance,—for there is no reason why we should not be on excellent terms. Dr. Dixon, who lately resigned in Dr. Mott's school, was much respected by our professors, and visited them at their houses. We shall cordially welcome Dr. Gross to our city—sorry as we are to have him a rival.

As soon as I hear from Wright again, I will inform you. Please let me know what are your favorite tribes of plants, and I will ask him to collect these especially for you.

I am my dear Sir,
with high esteem—
yours
John Torrey

[*George Engelmann to C. W. Short*]

St. Louis, Nov. 28, 1850.

My dear Sir:

Your letter of Sept 23 was received in due time, and would have been

answered sooner, if I had had any thing to communicate interesting to you. Your specimens sent to me so long ago have not yet, I am sorry to say, received the proper attention.

What you tell me about your acquaintance with our lamented friend Dr. Gregg is quite interesting and characteristic. If we could learn any thing more about him, to complete a short outline, you as the historian of western Botany and as Gregg's first instructor in Botany should publish a sort of necrolog in Silliman's Journal or some other work. I have written to a brother of our friend in Louisiana about some data, and also to learn, whether any thing had been left by Dr. Gregg in California, though I doubt that, as he had been there only in fall and winter.

Dr. Mead* sent me a package of plants for you a short time ago which I gave to Dr. Shumard of your city, who I doubt not has placed it in your hands by the time this reaches you. I wish we had a trustworthy Botanist to collect about the Salt Lake; I would pay a small share with pleasure; but Buckley makes very poor specimens.—Wright's are not very good, either, can not compare with Fendlers' or even Lindheimer's. —Where is he now?

What you tell me about your sojourn east was very interesting to me. If I could get away from my practice I would enjoy a few weeks east very much. But my medical practice chains me to the spot. You know that we again had Cholera here; though only about one tenth of what it was last year.—It showed itself again within this month! All that has kept me more busy than ever, and left me no time at all for botanical studies!—I am just now preparing Dr. Gregg's Magellan Collection for Prof. Gray, to be sent to England to him, to be studied.

If I can learn any thing more about Dr. Gregg I shall inform you of it.

Very truly
My dear Sir
Yours etc
G. Engelmann

P. S. I see in the papers that you are going to send a naturalist out to Liberia—is that so?

* S. B. Mead (1799–1880), a physician and botanist, born in Connecticut, who lived from 1834 until his death in Augusta, Illinois. He collected and studied the plants of his region and exchanged widely with the botanists of his day. He discovered the rare *Asclepias Meadii*, named for him by Torrey.

[*M. A. Curtis to C. W. Short*]

Society Hill, S. Car.
March 24th, 1851.

My dear Sir.

I was much gratified a few days ago to see your hand again, which was formerly so familiar to me. I must here declare, that it is no fault of mine that it has been so unfamiliar for the last few years. I have written once certainly, I think twice, since your last letter to me in Feb. 1846. I had however looked upon this cessation of correspondence as natural enough. We had little or no new matter to communicate, and in the love and eager search of something new we had gradually sought and obtained new sources of novelties, until we had insensibly lost each other. Still, I had not *forgotten* you and never shall. Though I have nothing new to offer you, it will give me pleasure to hear from you when you can conveniently devote a half hour to auld lang syne.

I have, as you intimate, exhausted the field around me, so far as Phanerogams are concerned. But long habit demanded the continuance of botanical research, and so I must needs look to Cryptogams for novelty. I have tried each Order of these, except Algae, and have at last settled down upon Fungi upon which I have been engaged for five years. These now enlist my interest as strongly as ever did the Phanerogams, and they have the advantage of supplying a large amount of new species. The field is large enough too, within the very narrow limits that I can occupy, to give me as much employment as I desire for the rest of my life.

As to the more important subject of your letter I cannot speak very positively. Ten or dozen years ago the house at the Warm Springs had a good reputation and was much resorted to. How things are conducted now I cannot say. Upon the quality of the Springs I can merely say, that they are *warm*, a quality that I never had occasion to covet during my rambles in that region. I once dipped my hands in to one of the Springs for mere curiosity.—But if you desire to pass a few weeks in one of the most interesting and attractive regions in the Alleghanies, I should recommend a sojourn upon the French Broad. A fine house is kept at Asheville, 30 miles above the Warm Springs, where you are within a day's ride of Black Mt., Pisgah, Balsam Mts., & Hickory Gap, the latter the most imposing gap in N. Carolina. I think the Shortia is to be looked for now upon Black Mt., and it would be a matter of no small interest if you should be fortunate enough to rediscover it.—Between Asheville & Warm Springs is abundance of Philadelphus hirsutus, Nutt. Below the Warm Springs you will find Buckleya (Borya

distichophylla, Nutt.) and in the mountains around, Andromeda floribunda, Pursh, all which are very rare. I have myself collected only the first, and not in flower. I have herborized but a single day along the French Broad.

I have it sometimes in mind that I shall have to take an excursion for health next Summer, and if you should conclude to go to the Warm Springs, and I go anywhere, I will join you there. In November last, in January last, and now again this month, I have had attacks of a sort of nervous Rheumatism, which wear sadly upon me. If I do not recruit at home, I must needs recruit abroad. I am now very feeble, creeping about house like a man of 80 yrs. But I hope to straighten up in a few days.

Let me know when you have concluded on your course. Dr. Hardy of Asheville, and also Mr. Clingman (*M.C. of some note*) of the same place are pretty familiar with the Mountains and can give you important directions, if you should wish to visit the mountains in that region.

Ap. 7th—After writing the above I was obliged to take to my bed again, where I have lain until yesterday. I hope the disease is routed for the present. As to a permanent cure, it is hardly to be looked for.

If you are inclined to turn your attention to Fungi, I shall be very glad to give you any assistance, in the determination of specimens, etc. The small sorts, growing upon dead leaves, sticks, bark, wood, etc. can be sent by tens & twenties in a letter. I receive them almost weekly in this way from correspondents. If you have good eyes, and can easily use a Microscope of 300 or 500 power, you will soon find beauty and variety enough among the Fungi to enlist a strong interest in them. With the fleshy species, or Mushroom, I would not advise you to meddle at first. These are difficult to discriminate, and troublesome to preserve.

I am feeble and do not feel like writing more. Let me hear from you again. Believe me

very truly your friend
M. A. Curtis.

[*M. A. Curtis to C. W. Short*]

Charlestown, Mass.
Sept. 9th, 1851.

My dear Sir,

I have just received your letter of Aug. 9th, which has followed me hither through the two Carolinas. I am obliged to you for the letter

from Reichenbach, to whom I will write some time. I doubt if I can do much for him.

I intimated to you in my letter of March last that I should probably have to leave home, if I did not make some progress soon towards former state of health. Three Rheumatic attacks in five months were rather more than I could stagger under without some unusual effort. I therefore left home the latter part of May for the Hot Springs of Virginia, a few weeks use of which worked charmingly. When I got there (June 17th) it was hard work to go up stairs, I was so feeble. On the 4th & 5th July I spent several hours in clambering over mountains. From that time I have gradually recovered vigor, and I am happy to say that I am now in good health.

If you had gone to the Warm Springs of N. C. and I had joined you there, as I thought I would when I wrote, you would for some weeks have had a poor companion in mountain excursions. I am sorry that your health is not very firm. I think you would find pleasure and health in a residence at the various springs of Virginia. The air is bracing, and the scenery attractive;—and if you are any way ailing, you will find some of the various waters probably suited to your case.—Some of these Springs are places of much resort in the Summer.

I hardly think there can be any mistake about the Shortia. It is an early flowering plant probably, and later Botanists have not been in the proper region by some weeks as early as old Michaux. Besides it might very easily be passed by for a Pyrola. I rather think, if I had a whole Summer to myself in those "hautes montagnes", that I could bring it to light. I would give no small sum to rediscover it.

Gray got home last week, and looks remarkably well. I was with him a short time this morning, and expect to spend tomorrow with him, though I shall have to be cautious how far I intrude upon one so industrious as he.

We have quite a number of eatable mushrooms, not only of Agaricus, but of Lactarius, Cantharellus, and Boletus. Some species of these genera are however desperately poisonous and no one should venture to eat any species unless he is quite familiar with it. There are no rules by which a poisonous species can be distinguished from the wholesome. If however you know the Ag. campestris, you know the highest flavored species we have, and need not desire another. I use myself chiefly the Ag. fabaceus,* *Berk:* first discovered by Lea in Ohio, and have a bed of it. It is very closely allied to the other, but besides a few other distinctive characters, it has when fresh broken a strong odor of peach

kernels, which belongs to no other known species. I should not be surprised if your "A. campestris?" was this.

The *Truffle* which Kalm alludes to, I have no doubt is the Pachyma Cocos,† *Fries*, found from Virga. ! to Texas, and sometimes larger than a man's head. It has no affinity to the Truffle. It originates on wood beneath the earth, mostly on roots of Trees, and is a solid mass of what Braconnot calls *Pectin*, but which Torrey long before had named *Sclerotin*. Of course then it is eatable as much as an Irish Potatoe, but is quite tasteless. It is known as Tuckahoe or Indian Bread.

An old German of Penna. told Schweinitz that in that State he had found the Truffle, hunting it with his dog as is done in Europe. This is all that is known of Truffles in this Country. No Botanist has seen one, and no one else can well be trusted. It would afford me great pleasure to get specimens from any part of N. America. I have 7 or 8 species from Europe. The name of the common Truffle is *Tuber cibarium*.

I expect to leave here on the 16th, spending a few days in N. York, two or three weeks in Phila., and to reach home about the last week in Oct.

I shall be glad always to hear from you, and will assure you of the continued esteem & respect,

of, my dear Sir,
yours truly
M. A. Curtis

* Not *A. fabaceus* Berk. but the plant that Curtis later called *A. amygdalinus*. As this name was never established by published description, the plant was later renamed *A. auricolor* by Krieger (Mycologia **19**: 308. 1927). See also Mitchell Journal **43**, p. 249, 1928.

† The real affinity of this peculiar growth, which is a parasite on the roots of various plants, was not known until 1922, when Dr. F. A. Wolf of Duke University proved it to be a *Poria* (Journ. E. M. Sci. Soc. **38**, p. 127, 1922). Tuckahoe has been known to reach the weight of 22 ½ lbs. (see note in this Journal **43**, p. 135, 1927).

[*John Torrey to C. W. Short*]

Princeton, Augt. 7th, 1851.

My dear Sir

A few days ago I received your welcome letter of July 24th. The enclosure for Dr. Knieskern* was forwarded to him immediately.

I know not what has become of Buckley, but I rather think he has

gone to California. He has not written to me since last autumn. You may be sure he is not offended with *you*, but I fear he thinks that *I* might have obtained a situation for him in California.

At the last accounts Wright was doing well in Texas. He expected to be in El Paso under the protection of Colonel Graham† and from thence to make excursions into the surrounding country. In this way he will probably anticipate much that the Mexican Boundary Commission hoped to accomplish. The botanists under Mr. Bartlett were on the ground last autumn, and although they will probably get all that Wright will find and more too, *he* will be *out* before them. Dr. Gray published (or rather printed) the first sheet of Plantae Wrightianae before he left for Europe, and, I suppose, will resume the article on his return, which will be about the 7th of September.

I hoped long before this to have sent you a copy of a little paper of mine on some new plants collected by Frémont in California, but there have been various hindrances in the way of its completion. It is now ready for the printer, and will soon appear in the *Smithsonian Contributions.*

I am right glad that you are getting more interested in botanical pursuits. At one time I was afraid you were going to retire from the field.

I wish you would send a young botanist into the mountains of North Carolina to look for the Shortia. What would I not give to see complete specimens of that plant! In studying the affinities of Pyroleae and Monotropeae lately I had occasion to refer to the Shortia. Really it is tantalizing to have such an interesting plant in our neighborhood, as it were, and not be able to lay our hand upon it. If I had less to do at home, I would find it, if it has not become an extinct species.

I keep at work every day (more or less) on our favorite science, and my zeal does not flag in the least. In this place, however, I labor under many disadvantages, chiefly from want of books, that I might command in a large city. I have sold my house in Princeton, and shall (D. V.) remove to New York by the first of November.

[Not signed but surely from Dr. Torrey]

* Peter D. Knieskern (1798–1871), a physician who botanized over the New Jersey pine-barrens.

† J. D. Graham, chief astronomer of the Mexican Boundary Commission. He was later replaced by Major W. H. Emory.

[*Asa Gray to C. W. Short*]

Cambridge, Jany. 17th. 1852.

My dear Dr. Short,

Pray forgive my delay in answering your kind favor of the 16th Dec. When it reached me both Dr. Torrey and Mr. Carey were with me, and the latter left us only last week. I have been much pressed by the printer with *Plantae Wrightianae*. I shall have the sheets to send you ere long; that is of part 1, up to the end of Compositae (some 200 pages). There I stop till I can take up the Monopetalae of this, Lindheimer's, Fendler's, etc. collections all together for part 2.

In Wright's letters (I had one yesterday) he expressed much anxiety about securing a set of his plants for you, to repay your kind advance and is troubled about it, lest his connexion now with the Boundary Survey (where he has a *small* pay) and the delivery of his packages to Col. Graham, should prevent his having control of them. But Col. Graham has sent the 1st envoi to me, and is bringing the second: and you may rely upon my looking after your and Wright's interests. I trust that Graham will be content with a single set for Government, when besides yours, there will be several others to turn to Wright's benefit. The portion I have got abounds in *very interesting* plants.

May I not hope that you will soon make a second visit eastward, and allow Mrs. Gray and myself the great pleasure of welcoming you here!

I am glad you will prepare a notice of Gregg. In the 1st sheet of *Plantae Wrightianae* printed before I went abroad (I thought I had sent you a copy) you will find a curious new genus of Cruciferae, which I have dedicated to Gregg's memory. I have also figured it. You shall have it ere long. If you look through Pl. Fendlerianae, the 2nd Pl. Lindheimer[ian]ae, and the forthcoming Pl. Wrightianae, you will see continual notices of new things from Gregg's collections. That region was almost all new when he began. Torrey has spoken of the parcel he left at American Institute, New York, and fears it is by this time eaten up by worms.

You will find the mountains of Carolina most delightful for summer. I long to have another summer there, and still dream of its mountains, wooded dells, and innumerable streams of purest water. I advise you to go up the *Kanawha*. In Kanawha Co. Virginia, the Rev. Mr. Brown finds *Sida dioica* wild! and plentiful. There is very wild scenery on that river in Virginia. I have never been there. In the spring, before you set out, let me give you something of an itinerary. I am too hurried now, to do it properly. But I would by all means have you explore the deep valley behind Table Mountain, North Carolina, and take from

thence Michaux's route to the *Black Mountain*, a route where it is now most likely Shortia came from. I think it not unlikely you may find it. Asheville, N. Car. is a fine place for head quarters—good society and ready access every way. Thence make one good trip to Balsam Mts., Devil's Court House, and Table Rock, and thence out into the northern end of Georgia. I had not time to get into Georgia, and the whole region where the three states corner has been very little explored yet. Remind me to write you again in the spring, before you set out.

I did hope to have been at work on the rest of Vol. 2 of Flora ere this, but, tho I waste no time, have not got on so far yet. I have to work at Exploring Expedition collection, as well as other things. I will do my very best. I addressed a small pamphlet to you lately, with some botanical information.

I have just (in Pl. Wright.) dedicated a fine Leguminous genus to the memory of Dr. Peter,* your former associate: there are fine specimens of it in the collection of Wright 1851, which you are to share in.

Does not Mr. Griswold† deserve generic commemoration?

Carey was to have written to you, while here, but we had not time. He is a prompt correspondent, and you will hear from him soon.

Sir Wm. Hooker, always asks after you with unabated interest. We spent much time at Kew, where I worked to great advantage.

Trusting to hear from you duly again,

Believe me to remain

Yours most faithfully

Asa Gray

* Robert Peter (1805–1894), physician and chemist, born in Cornwall, England; came to Pittsburgh, Pa., in 1817. In 1833 he became professor of chemistry in Morrison College in Lexington, Ky. He studied medicine but soon gave up practice. In 1838 he was elected to chair of chemistry and pharmacy in Transylvania University and held this position until the closing of the school in 1857.

† Henry A. Griswold, professor of mathematics, etc., in the Eclectic Institute of Lexington, Kentucky. He was intensely interested in botany and helped Dr. Short explore various regions of Kentucky for plants (see page 99).

[*John Torrey to C. W. Short*]

New York, Jany. 19th 1852.

My dear Sir—

I received today a letter from Mr. Wright, enclosing one for you, which he requested me to forward. In a P.S. to mine, dated Dec. 10,

he informs me that Major Emory had arrived at Frontera (above El Paso) and had relieved Col. Graham, who would return immediately to Washington and take with him the botanical collections of the present season. When Col. G. took Mr. W. into his party the poor botanist was in rather a hard case. The great expenses of travelling and transportation had consumed most of his funds. He accepted a place under Col. G.'s command with the understanding that he was to receive a small salary—but the Col. insisted upon having the control of the entire collections. He did not say what he intended to do with them—but I have no doubt he merely wished to secure for the Commission, the credit of first publishing the new species, and then to let Mr. Wright have the disposal of a part of the collections. The results of last year's labor, (I mean those of 1850) are now safely in Dr. Gray's hands, where I saw them in a late visit to our friend. He is publishing the new species in his "Plantae Wrightianae," a memoir now in press for the Smithsonian Contributions. He will keep them subject to Col. Graham's order—unless they should pass to the charge of Maj. Emory. You may be almost certain that a full set of them will be received for you. If they are turned over to Maj. E. I promise you a good share—for the Major will place them (as well as all the subsequent collections) in my hands. If Dr. Gray retains the charge of last year's collections, you are equally sure of the plants.

I was at Dr. Gray's when your letter to him was received, and I presume he has replied to it ere this. You have doubtless read his notice of the state of Botany in Europe, and of the doings there for two or three years past. He is now laboring assiduously at his favorite science, and has quite eclipsed his old preceptor—for I suppose you know that he was my pupil until he was able to teach me.

I am now occupied in delivering my regular Chemical Lectures in the Medical College—but I find time to devote several hours to Botany. I have sold my place at Princeton, and have taken up my quarters once more in my native city. Indeed I always felt as if I were more of a New Yorker than a country man. Our college term has been so much extended and it is so unpleasant to travel backwards & forwards in the winter, that I concluded to have my home in New York, and spend two months or so in Princeton in giving my lectures there, for I retain my professorship in the college of New Jersey. You may wish to know how we succeed in New York. Our school has about 230 students (more than usual) and the University School not so many—though they place more in their catalogue. The 3rd school (established last winter) has about 50 students.

You will be amused at receiving the other letter from me enclosed with this. It was begun long ago, as you will see by the date—and laid aside to finish but got overlaid with a heap of papers and only turned up the other day! I send it in the state in which it was left.

Pray keep in mind what I have written about the Shortia. It is probably a spring plant, and may disappear after flowering and perfecting its seed. Someone should be pretty early on the ground to find it in flower. If, however, we could get the living roots there would be no difficulty in cultivating it. Even if the plant were not found, a botanical expedition to the N. Carolina mountains would be desirable, for the botany of that region is by no means exhausted.

Yours cordially—

J. Torrey

PS. I have just received a note from Mr. J. Carey Jr. inquiring as to the composition of the material used by his father for sticking his plants to paper. It seems that he wishes to give the information to you—so I took the liberty of replying to his note by stating that I would write to you myself.

The adhesive material is a mixture of *pretty strong* common glue (the pale kind) and a solution of gum ammoniac in proof spirit. A saturated solution of the latter added to twice its bulk of glue, in the condition in which it is used by joiners. It is applied to the dried specimens in the ordinary way.

J. T.

[*John Carey to C. W. Short*]

New York
18th March, 1852.

My dear Sir,

Your valued letter of 17 Dec. reached me at Cambridge, whilst spending a month with our friend Dr. Gray. About the same time he also heard from you, and it was arranged between us that he should reply to your queries as to the best route for you to take amongst the Southern Alleghanies, as he has been there three times, & knows more of the (botanically) unexplored parts than I do, myself—Especially, he has a fancy that he knows the probable track of Michaux in which the *Shortia* may be sought, with a chance of success; and who so fit to find it as your good self? If the Dr. has not already done so, ask him to write you, on the subject, and remind him as to the name and whereabouts of

Michaux' old *guide*, whom he saw, and from whom you may learn this track, in general, if not particularly.

. . . . etc.

With many thanks for your kindness on such occasions, believe me, my dear Sir— faithfully yrs.

Jno. Carey.

[*J. H. Lundgrenl to C. W. Short*]

Charleston, S. C., May 8th, 1852.

Dear Sir,

Having to express my feelings for your liberality, I feel very much embarrassed, being, as I am, but little versed in writing English. Nevertheless, indebted to you beyond description, I must beg you to be contented with my declaration that I fully appreciate the liberality and the love to the "lovely Science" which have induced you to make me an object of your kindness. The only way I can duly acknowledge your goodness I will try to go on, viz. to use all my power in fullfilling the purpose of my journey. Being stranger to many features of American vegetation, yet I hope to be as much acquainted with the same as a collector *necessarily* must be, and I expect to be able to do something for the knowledge of the Lichens and Mosses in the interesting regions I am just going to see.—I have received here in Charleston much valuable information from Prof. L. R. Gibbes,* in whose house I live at present and from whence I intend to set out on Monday morning for Asheville, N. C., this place being, I think, the first best *headquarters* I can take in N. C. My plan is to set off from Asheville in westerly direction and, as much as possible, look out in Cherokee County, N. C., this county being, I suppose, the least explored in this state.—Of course, I intend to keep an exact account of all expences [sic] and I will try to get all necessary things as cheap as possible, but as your main object seems [to] me to be to get large collections and *fine* specimens, I think it be obvious that I cannot some times avoid expences, f. ex., if I intend to get along from one place to another by foot, I must of course send my luggage by some means, and at the same time it can happen that I must pay a man to guide myself. In any case, I will avoid all expences which are not manifestly of necessary or immediate utility for my purpose.—

Pro ceteris autem dictum volo, me liberalitatem tuam & benevolen-

tiam animo gratissimo amplecti. Fac valeas, vir esteematissime [sic], et in scientia incrementum decusque longe lateque vigeas!

Observantissimus tui servus

J. H. Lundgrenl.

* Lewis Reeve Gibbes (1810–1894), professor of mathematics in the College of Charleston for over fifty years, and a versatile naturalist of great distinction. He wrote the *Catalogue of the Fauna of South Carolina* (Appendix to M. Toumey's Geology of South Carolina, 1848), *On the Carcinological Collections of the United States* (Proc. Amer. Assoc. Adv. Sci. 3: 167–201), in which twenty-two new species of crustacea were described, *Catalogue of the Phaenogamous Plants of Columbia, S. C.* (Columbia, 1835), as well as other articles on botany, astronomy, physics, etc.

[*Asa Gray to C. W. Short*]

Cambridge, 22' Nov., 1852.

Dear Friend

By this time you must have a second letter from me, I having, in the multiplicity of my doings, forgotten that I had written already the letter answered by your favor of the 12th inst,—just as I forgot that I had already sent you via New York a copy of *Pl. Wrightianae.*

Please to use the duplicate (for such it is) for any friend to whom it may be really useful.—Or if there be none such near you—keep it for me—as the supply of copies is small.

The Part II, which answers to the collection of plants sent, is printing. I have read a sheet or two of proofs.

The Boundary Commission being broken up, at least temporarily, Wright has accepted the post of botanist to Ringgold's* Expedition to the N. Pacific, Sandwich Islands—& N. W. Coast—to be off in January.

Yours of June last, with Fraxinus 4-angulata [quadrangulata], came duly. Since then I have from Sullivant & Cooley good *fruiting* specimens of this species.

I should like some *flowering* specimens of it next spring (by mail) We shall yet hope to see you here, if we live.

The bit of Texan plant enclosed belongs to an *Acalypha* also gathered by Drummond, Wright, etc.—but, so far as I know not yet published or named.

In haste

Yours faithfully

A. Gray

* Cadwalader Ringgold (1802–1867), naval officer, born in Washington County, Md., was in command of the *Porpoise* in the Wilkes Exploring Expedition 1838–

1842; cruised along the antarctic continent, surveyed on the west coast of America; commanded the North Pacific surveying and exploring expedition which left Norfolk in June 1853; charted Pacific shoals and islands, and reached China in 1854.

[*Asa Gray to C. W. Short*]

Cambridge, 10th Jany., 1853.

My Dear Friend

I received to-day your favor of the 4th inst. with the check of $36.—which I put to Mr. Wright's credit.

My Memoir, which will name all the plants in the parcel you have received, is two-thirds printed; and I hope you will soon have it.

Of course, many of the plants are named in my 1st Memoir—(the coll. of 1849). Those are distributed under a different form of label, with the year on it, so that no confusion can arise. The nos. run on consecutively from one set to the other.

I am mortified at my blunder about Dr. Peter. I did not confound him with the late estimable Mr. Eaton.* But, if I rightly recollect I had the information that he was dead from Dr. Torrey.

His name occurred to me while working up the Wright plants at Hooker's, 2 years ago—so that I could not have corrected it at the time. But I rested in the information I thought I had received.—

Well, Well. The proper place to correct it in my new Plantae Wrightianae has passed by.

He seems to be dead to Botany, any way

In haste

Yours faithfully

A Gray

I think you had better give the copy of Pl. Wr. to Dr. Peter, with my regret, and humble apology for the *homicide*.

A. G.

* H. Hulbert Eaton (1809–1832), son of the well known botanist Amos Eaton of New York state. He was assistant professor of chemistry in the medical department of Transylvania University and greatly interested in natural history.

[*John Torrey to C. W. Short*]

New York, March 19th, 1853.

My Dear Sir

Your letter of the 9th crossed one from me to you, which I hope you received several days ago. The Daguerreotype of your kind face was

handed to me by Prof. Silliman's* assistant. It affords me great satisfaction to possess it. My family say it is an excellent likeness—and I have already boasted to Dr. Gray that it is far better than the one which he possesses. When I get into my new house (which I trust will be in three weeks), I hope to set apart a small room for portraits of botanists. My wife has agreed that an entire story shall be devoted to the herbarium and botanical study.

You do not inform me whether Dr. Gray has sent you the two parts of Plantae Wrightianae containing descriptions of the specimens collected by W. in Texas and New Mexico. If they have not been sent, you ought to have them. I have just inserted a mem. to that effect in a letter on my table for Dr. Gray.

I have been looking out for an advertisement respecting the next meeting of the Amer. Assoc. of Science. Circulars were sent to nearly all the members, to ascertain whether they were willing to meet in *May*,—at Cleaveland—but I have not the result. If the meeting *is* held there, I hope to go, and then to have the pleasure of seeing you *in situ*.

With high regard, remain yours

John Torrey.

* Benjamin Silliman (1779-1864), professor of chemistry and natural history at Yale and founder of the American Journal of Science, which was long known as "Silliman's Journal."

[*Asa Gray to C. W. Short*]

Cambridge, Nov. 24, 1853 (Thanksgiving)

My Dear Dr. Short

Your very kind letter of the 10th inst. reached me while I was absorbed in the preparation of a couple of public lectures, which gave me a deal of work, and I delayed replying till they should be off my hands—which is now happily effected. Now I may resume my correspondence, and first of all in value is your epistle.

You may, if you have not already done so, give to Dr. Peter, the 2nd copy of Plantae Wrightianae, pt. 2.

I meant to have been at work at the rest of Pl. Wright. ere this: but Exploring Expedition Botany has kept me back; besides lately an intimation from Maj. Emory, that he would like to have some of his Report on Boundary Commission plants in general (that dear Dr. Torrey is slowly working at) come out first,—and I am always ready to oblige.

I expected Torrey to be with me to-day, that we might among other things consider about Berlandier's* Collection. But he now writes that he cannot visit me before Christmas.

If that collection is as large as Dr. Baird† leads me to suppose, and if it comprises sets of all the plants which he sent to Geneva, and which are distributed in European herbaria, and frequently referred to—as you see in all the later volumes of DeCandolle's Prodromus—it would be a very valuable collection, at least to me—as enabling me to identify a great many species founded in Europe on these collections—while those since gathered would have many novelties. If I could at all afford it I would buy the collection,—more perhaps from its having authentic originals of species already published in Europe, than for unpublished things. I should like at least a set out of the things.—And what I proposed, viz. the publication of figures of 50 or 100 critical species, about which there may be something to be said, would be a real benefit,—and, I still think, a very proper thing for you to do—in the mode of Delessert's‡ Icones Selectae of plants published in the Prodromus of DeCandolle. (I dare say, that Berlandier was not a very honest fellow—and this might, in that view, be doing his memory too great honor. I was only thinking of the use to science.) About this, hereafter. I have written for more information about the collections. Perhaps even it may be best for me to run on to Washington and inspect them,—as a look would be worth more to me than any account any-body could give me.

About the remaining matters on which you so kindly write to me. I only wish I could verbally give you an account of the whole state of things—which my time and my tired wrist does not permit me to write about as fully as I wish to.

I dare say the *Genera Illustrata* has not yet paid back its draughts on my purse. If it has nearly so, then its continuation would not involve me much. But that is not so much the difficulty:—And as regards the *Flora* not at all so (that has and would pay its way, which is all we ask). In regard to them and the other works I am so deeply loaded down with: the great desiderata are—1. *time*—Oh, that you could give me more of that.—2. *Botanical workers.* I could supply 5 Botanists with work to do for a life-time. Now *we* have lost Carey, there is no one who is any help.—If I could ever find a trusty assistant who could do much of the half-mechanical work, it would be a great relief.—But every one I have tried is as much trouble as service.—3. *Another Draughtsman.* Sprague§ works *very* slowly—will not be driven—and has feeble health—yet is

invaluable. You will be delighted with his folio Exploring Expedition drawings. Even there he does not do *half* fast enough,—tho, to do them he has for a long while—to *drop* Forest Trees drawings—(which nevertheless I have promised Prof. Henry a volume of next summer or fall)—has to drop *Genera Illustrata*, entirely. For though I do not work as fast as I always expect and lay out to—by a great sight—yet I could bring out vol. after vol. of Genera Illustrata—and new Pl. Wrightianae, etc. etc.—if Sprague could only accomplish the drawings.

I have long been seeing it perfectly necessary to have a 2nd artist—and Torrey wants another—There is more work than 3 can do—and I have now decided to write to friends in Paris (how I miss my dear and excellent friend Adr. de Jussieu!) and see if I can import one. In this I must assume responsibility and probably make advances during the 1st year, or more—tho, I do not doubt finding plenty of occupation for him that will remunerate well, at length.

In this way I may hope to accomplish more for science. My next 10 years, if it please God that I have them here, should be my best ones, and should accomplish the greater part of the work I may hope to do. I am 43 years old this week! I can just barely get on comfortably with my salary—having no children, and my dear wife some $3000 capital accumulating interest for her future, and ultimate expectations of perhaps $8000 more, we have no anxiety on her future account—So that the doing the work incumbent on me to do as Professor—and as an American Botanist, is just the work before me—which I engage in with alacrity, and with satisfaction, and single-mindedness.

But I must for the present break off this gossip and mail my letter—Will write again soon.

You know dear Carey has *married* in England,—is very comfortable—and now has sent for his library and herbarium.

Believe me to remain with strong desire to see and know you personally

Yours very faithfully
Asa Gray

* Jean Louis Berlandier, a native of Belgium and pupil of DeCandolle of Geneva, who came to this country about 1826 and set up as an apothecary at Matamoros, Mexico. Later he made extensive collections of plants in Texas, financed by DeCandolle, M. Dunant, and other subscribers.

† Spencer Fullerton Baird (1823–1888), zoologist, born at Reading, Pa. Became professor of natural history at Dickinson College, Carlisle, Pa., in 1846; assistant secretary to Joseph Henry at the Smithsonian Institution in 1850, and succeeded him as secretary at the latter's death. He wrote several important

books on American birds. In 1871 he was made head of the U. S. Com. of Fish and Fisheries, and he was one of the earliest workers in marine biology at Woods Hole, Massachusetts.

‡ Baron Benjamin Delessert (1773–1847), a French financier and philanthropist who was associated with DeCandolle in the publication of *Icones Selectae*.

§ Isaac Sprague (1811–1895), a skillful and prolific botanical artist, was born and lived in Massachusetts. He made the fine drawings for Gray's *Genera Illustrata*, as well as many others of his works. Sprague was also interested in birds and in 1843 accompanied Audubon on his expedition to the upper Missouri to help with the drawings and sketches of birds. The herb *Spraguea* of the Sierra Nevada region was named for him by Torrey.

[*Asa Gray to C. W. Short*]

Cambridge, 24th, 1854. (*June*)

My Dear Dr. Short

These are most busy times with me, the very press of college and other work, but I must acknowledge your friendly letter of the 10th inst,—particularly as I have to-day taken a decided step about the Berlandier collections of plants.

I have never been able to go to Washington yet, to examine it; but I asked our good friend Torrey to do so, when he was there at the meeting of the Scientific Association. He wrote me that there was a great mass of specimens, tolerably good working specimens, about as good as Drummond's Texan Collections, and in good preservation so far as he examined,—that the owner wanted $500 for them, and that he thought them worth it, considering the importance of having in our herbaria the species so largely cited in the later volumes of DC. Prod., etc.—and apparently a great many besides:—thought I had best advise you to purchase them on the liberal principles of advancement of Botany which you had suggested, but felt shy of advising it himself, on account of the bad issue of his advice in respect to that Swede,—which Torrey can hardly get over. I had felt determined however, not to offer more than $400—at least until I saw for myself reason for going higher. I greatly doubt if I should advise anything more on inspection; but Torrey's report was certainly in their favor. I determined to wait until Torrey came to see me,—which was to have been early this month. But it was postponed on account of my being too much occupied, until about the 4th prox.

To-day, however, a P. S. in a letter from Prof. Baird, to whom the owner has entrusted the collections, speaks of them,—that he would like to have them disposed of before he leaves Washington for the summer, etc.

Fearing that they will deteriorate where they are, I concluded to run the risk, and have offered $400 for the collection of plants—with the mss. that relate to them,—or the use of the same,—to be boxed and shipped at the owner's expense (I to pay the freight pr. vessel to Boston).

I shall soon know if the offer is accepted. If not I will make no other at present. If accepted, and they are sent I will examine and report on the collections; and we will then consider what had best be done with them.

The 1st Vol. of Botany U. S. Exploring Expedition is now out—at least the text—about 800 pages 4to—but very open style of print. The Atlas of 100 large folio plates not yet out, Sprague not having finished the drawings. I have disposed of the greater part of my extra copies to Putnam & Co. New York, so as to recover my expenses and have some copies for foreign correspondents, etc.—The text to sell for $10—the Atlas for $15. If you care for it, encourage Putnam & Co. by ordering what is out, without waiting for the Atlas to be published.

I am now working up odds and ends—at such bits of time as I get, and making ready after Torrey's visit to set to with vigor on Pl. Wrightianae, Lindheimerianae, Fendlerianae, Flora of N. Amer. rest of vol. 2 and some Exploring Expedition Monopetalae—all together. I hope I may accomplish something.

I have pleasant letters from Hooker—and lively scientific ones from his most energetic son Dr. Hooker—a young Hercules—Kew is getting to be the great focus for Botany. Bentham, you know, has bequeathed his herbm. and library to Kew—he to have unrestrained use of it during his life—and it is already deposited, with Hooker's vast one in the King of Hanover's house close to Kew Gardens—and Bentham has removed from Herefordshire to Kew, to be near it, and some botanist from various parts of the world is there—often 2 or 3 at once, all the while.

They miss Wallich* very much. He died at the age of 68.

Good draughtsmen for Botany are indeed desiderata everywhere. Fitch in England and Rivereux in Paris (the best one living—better than Sprague as an artist, probably, but he does not put so much science into his work as I have taught Sprague to do) are the only really good professional ones. *We have got two women at work with Sprague now, —they can help some—and perhaps they will soon be able—or one of them—to do something more—but it is slow training them, and not very hopeful even.

If I could draw at all—anything like what Hooker and Harvey can—I could save much time, by making sketches as I dissect & study.

Torrey giving up Princeton, I think will hereafter have quite as much time for Botany as he has had for several years. He gives up a place that paid only $700 and took him out of New York and made much travel back and forth, and takes at the Assay-office a more regular, but less worrying work—and gets $2500 for it, and has a good assistant allowed him. When he gets settled in it I trust we shall get more steady botanical work out of him.

I doubt if Carey will work much more at plants—though he will find time to enjoy his herbm. I trust. He is only about 12 years older than I am. Still he might work much at plants; except that when engaged in business, it always absorbs his powers very much.

I fully appreciate what you write about *children;* and must have badly expressed myself in my former letter if I spoke of the privation as a hardship. I am perfectly content with what a wise and good Providence *withholds* as well as what it has given, and feel the great comfort, situated as I am of the freedom from anxiety for the future, which a family must needs entail. God forbid that I should repine for a moment. Indeed I never had any occasion to in all my life. But one's wife, however convinced it is for the best, would hardly be a woman if she did not long for children.

I think I wrote you that I have bequeathed my herbarium, etc., to Harvard College, on condition of a small annuity to my wife should she survive me and need it. Without children to provide for I can, without injuring any interest or neglecting any duty, continue to build it up, and leave it as the foundation of a very important collection for North American Botany, and in such a way that I might expect it to be taken care of, and continued by my successor.

But, in this busy country there are no young botanists coming on to take our places, that I see. I long for at least one good, promising fellow to turn up, and would gladly set him at work under advantages a hundred times greater than I ever enjoyed. There is a good deal of scientific talent and taste in my present College Class,—but they will all be drawn off into other more lucrative pursuits;—and I cannot wonder at it, nor indeed wish it otherwise:—until the young man turns up who *cannot help being* a botanist.

Do you not mean to come this way again—perhaps this summer. Pray, if you do, arrange to make us a visit, of some time. I long to see you.—Ever Yours faithfully

Asa Gray.

* Nathaniel Wallich (1786–1854), a Dane by birth, and a student of East Indian plants.

[*Asa Gray to C. W. Short*]

Cambridge, July 6th, 1854.

My Dear Friend

Prof. Baird's letter, received to-day, apprises me that Lieut. Couch accedes to my offer of $400 for the Berlandier Collection of plants; and that it is being boxed up for shipment to me. A condition annexed has only now been made known to me, Dr. Torrey having omitted to mention it—though he thought he had,—viz. that as good a set as well could be should be reserved for the Smithsonian Institution.

I have informed Prof. Baird that under ordinary circumstances, I could not have offered the above sum, subject to that condition. But that, the purchase having been made with the special view of rendering the collection most subservient to the advancement of American Botany, I could recognize a propriety in the condition; and that I agreed that as fair a set as could be spared of the plants should be *presented by the purchaser** to the Smithsonian Institution:—which Institution should, I thought, in this view, pay the freight of the boxes by ship to Boston, and see insurance on $400.

I trust this will meet your approval. We will consider what had best be done with the collections. Meanwhile, I think I will not draw on you; but leave you to remit to me by mail, a check on your Philadelphia bankers for $400, payable to my order, which I will endorse over to Lieut. Couch and forward as Prof. Baird shall direct, when the collection arrives, taking his receipt for the same.

Dr. Torrey is here on a short visit,—and sends his warm regards. He will soon visit me again. When I wish you could join us,

In haste

Yours very faithfully

Asa Gray

* i.e., Dr. C. W. Short.

[*Asa Gray to C. W. Short*]

Cambridge, 25 July, 1854.

My Dear Friend,

I hasten to inform you that I have received your letter containing a check for $400, to pay for the Berlandier Collections of plants; which, on arrival of the boxes, next week, I shall endorse over to Lieut. Couch, or Profr. Baird.

Prof. Henry promptly acceded to my proposition. He pays the freight from Washington to Cambridge; and I agree that the present owner of the collection shall *present* to the Institution as fair a set of the plants as can properly be spared. From what Dr. Torrey said I suppose there will be 4 or 5 pretty full sets. But I will report on the matter, as soon as I can examine the boxes, on their arrival.

I thank you heartily for your generous proffer of the fullest set for my own herbrm. If I accept it, it is on grounds connected with the importance of my herbarium for those who are to succeed us—and I have made provision—and will more fully provide (Deo favente) for the preservation and future utility of this herbarium.

I will have a printed form of ticket; but that will cost little, and I ought to be very glad to assume the charge.

Expect to hear from me when the boxes arrive and are opened. After my reporting on them, you can best judge what disposition is to be made of the plants.

I had thought that the 14th vol. of DC. Prod. was all printed. But DeCandolle lately informed me that the printing had barely begun. It will not be issued therefore, before the close of this year.

In haste

Ever Yours faithfully

Asa Gray

[*Asa Gray to C. W. Short*]

Cambridge, 29th July, 1854.

My Dear Friend

The enclosed reached me to-day, from Dr. Stulz of Hamburg.

Of course it should not require a request that I should acknowledge your favor, enclosing the check for $400—Arriving on our Commencement day it got a little postponed; but ere this you have my acknowledgment. The check is still in my drawer, as Dr. Baird has not yet advised me as to the mode of remitting it.

The boxes have safely arrived. I have opened 2 of the largest, and have examined a number of the packages.

The specimens are poorly dried—as I knew before,—the greater part appear to be under *numbers*, I think the same that they were sent to Geneva under, and distributed in Europe.

I see as yet no dates later than 1840.

The numbers run to over 3000—and I know not how much farther, but I already see that the same plant occurs over & over under different numbers.

Of many only one or two specimens occur under each number. In other cases there are from 4 to 10. A great deal is mere rubbish, except that a specimen under a number it has been distributed by is always important, for identification, etc.—others are very fair working specimens,—though not handsome and not pressed hard enough. I shall probably find, in some one of the boxes, some memoranda, by means of which I may make sure what has been sent abroad. I will also write to Hooker, to learn how high his numbers run, and to Alph. DeCandolle for similar information.

The main thing now is to distribute as soon as possible all that is worth preserving into sets, as far as they will go.

Thus far I should judge that they will make *6 sets*, of which no. 6 may contain 1/3rd & no. 3 [may contain] ½ to 2/3rd as many as no. 1.—But if we put the same things together—tho. under different numbers, I suspect 3 or 4 sets may be made very nearly complete, and as many more of half size.—But I shall discard much trash.

There are also many specimens of *woods* numbered,—no catalogue found as yet.

This will give you some idea, so that you can consider what is to be done with them.

Will you have a full set yourself, as possible?

Any that have not gone abroad *should go*, to Herb. Hooker, DeCandolle, Paris Museum, etc.—But I know not yet how many such there are.

The Texan part of the collection is familiar to us in much better specimens, of Lindheimer, Wright, etc.

I will have a label printed for distribution. Say thus—

Yours cordially
Asa Gray

Herbarium Berlandierianum Texano—Mexicanum
No. ——

C. W. Short donavit.

[*Asa Gray to C. W. Short*]

Cambridge, 24th Oct. 1854.

My Dear Friend

My wrist is fatigued with overmuch writing this evening, so expect not a legible scrawl. Some collections lately in that I have to name in haste for Torrey, etc.—have interrupted my regular work, and prevented my passing an hour or so each pleasant afternoon, as I was wont, in distributing Berlandier's collections. This I have done in my barn (used for little else, as I do not keep a horse); and I hoped to have been done with it before cold weather came on. I shall, however, have to finish in the house.

I had satisfied myself that the latter part of the collection, i.e. from 3050—down to 2353, had not been sent to Europe for distribution; but that we had the whole stock. For they distributed out, with very few exceptions, into 13 sets, and of half of the species there were several from 2 to 15 specimens more.

I have found, however, one serious break in this portion—i.e. I find none from no. 2580—up to 3000—, and one or two lesser breaks occur—which perhaps some of the bundles yet to be opened will supply. After coming down to 2353, the specimens become few, i.e. from two to 6, rarely 7–9. Of these I lay none out for DeCandolle (as he is supplied to this point); but put as many as I can into the set intended for Hooker—as I feel that they will be more useful for American Botany there than anywhere else, except in my own herbarium—for which I retain a full set—whether rare or common, good, bad, or indifferent specimens.

The same species occurs over & over again, under different numbers—so that I doubt if the latter part, not distributed in Europe will add many species to the list, tho. they are generally much better specimens than the earlier ones, as well as in better preservation.

Well knowing that you do not approve of bad specimens, and feeling at the time that the greater part might turn out poorer in this respect than they do, on the whole, I decided not to put your name on the printed ticket:—as thus far your name has always been affixed to a nice and handsome specimen.

I am carrying on the distribution in such a way that, as soon as finished, I shall be able to give you a report on its extent, the mode of distributing, etc.—and not long after furnish you with names for no small part of your set.

I meant to have written to you soon after receiving Hooker's letter of Aug. 15—enclosed.

On reflection, I remembered that Hooker's herbm. did not contain numbered sets of Berlandier plants—in fact had only a few, of the character he says. I have therefore provided for him as fully as he will require or care for.

DeCandolle's letter arrived only 3 days ago—I thought you would like to see it.

We can very well supply a tolerably full suite of the undistributed part of the collection to M. Dunant and I should like to do it, if you say so.

DeCandolle (Alph.) is a much valued friend of mine—and he, as well as other Geneva Naturalists have always furthered my desires and facilitated my inquiries in the most prompt and liberal manner.

I must set about obtaining for DeCandolle the information he asks for about Berlandier.

Let me say that the collection will be quite as important and useful to me as I ever supposed it could. It supplies the authentic originals of a great many species; and the unpublished parts abound in interesting plants—many of which I have published from other collections—but a good number are still unpublished.

Of the spare sets I design one for the Royal Herbm. of Copenhagen,—whence Prof. Liebmann*—who was long in Mexico, and is now working up a very large Mexican collection, is to send me duplicates of his Mexican plants.

I have lately a parcel from Stulz, in a Hamburgh package, long on the way. It contained nothing for you. Have I not forwarded something from him since your favor of Aug. 15th—so long unanswered. I have some vague idea of the kind.

Hoping to write again soon, I remain, Dear Dr. Short

Very cordially Yours

Asa Gray

* Frederik Michael Liebmann (1813–1856), professor of botany and director of the Botanical Garden at Copenhagen. His *Chênes de l'Amérique tropicale* was published in 1869.

[*Asa Gray to C. W. Short*]

Cambridge, 17th Nov. 1854.

My Dear Friend

I have your esteemed favor of the 4th, to which I make a hurried reply.

You did not return Sir Wm. Hooker's letter—It is of little moment, however. Ere this you will have heard from [him] directly, as his last to me mentioned his having written, and also sent some publications by the hands of a friend & neighbor of yours.

You are welcome to keep DeCandolle's letter (at least till you get one from him directly, as you [he?] will be sure to write, on receiving the parcels I am to send): but I shall have to trouble you to have a copy made and sent to me, as it contains some matters about the nos. of Berlandier's plants, etc.—which it is needful I should have.

Both the weather and the pressure on my time have prevented my going on with the distribution of Berlandier's plants for some time. I hope soon to resume it, of an evening, in my study,—which will not be difficult, since the specimens of the present part of the collection are only 1, 2, 3, or 4 of each number—and those not very good ones. I think it is about to improve again further on. The *complete sets*—in considerable number are restricted, you know, to the part of the collection not formerly distributed in Europe. I am sure Mr. Dunant would not accept any part of the collection at the sacrifice of your sets,—nor does he need any except of the part not sent by Berlandier and distributed,—and of this portion there is an abundance—and I propose that a full set of them shall be sent to him.

By to-day's post I will write to DeCandolle and say this, and your perfect willingness to yield any claim in their behalf, or make up, as far as may be, for Berlandier's shabbiness.

Wright sent the real *Lucerne* (*Medicago sativa*)—I think under the name *Alfalfa*—but am not sure.—It is cultivated in N. Mexico, Sonora, etc.—also in S. America.

It is a good deal cultivated here by our gentlemen farmers, for *Green food*, for stall-fed cows, etc.

I knew Lapham* was illustrating our grasses in the manner you mention, and I have received from him a proof, which looks very well indeed.

Ever, Dear Sir,
Yours sincerely
A. Gray

* Increase Allen Lapham (1811–1875). He was born in New York but from 1836 made his home at Milwaukee, Wisconsin, doing various engineering jobs and writing on geological, botanical, and antiquarian subjects. He was an expert map maker.

[*Asa Gray to C. W. Short*]

Cambridge Feb. 5th, 1855.

My Dear Friend

Your favors of the 6th & 8th both reached me duly at Washington. And on my return home late last week, your box for Sir Wm. [Hooker] met my eyes. I was not in time to send it last week, and thought it best not to entrust it to my Express-man for shipment, lest some thing should go wrong.—But it shall go next week.

Your letter to Sir William I shall enclose in one of my own to be written this evening and dispatched via N. Y. steamer of Wednesday.

I need not say that it will always give me great pleasure to act as an intermediary in your correspondence with Hooker, or any other foreign botanist. Sir William is one of my nearest and dearest friends—now of almost 20 years standing.

I had a pleasant time at Washington—as did Mrs. Gray. I gave 9 lectures on vegetation—3 a week—to a very handsome audience—and had frequent conferences with my good friend Prof. Henry. He is well sustained by the Board of Regents, and I trust will be by all other authorities. He is not only wise and large-minded, but one of the most honest, incorruptible, and unselfish of men.

Not only all men of Science, but all good and true men should give their influence to sustain him, against malice, hatred, and falsehood.

I am clearing off a huge pile of letters, preparatory to setting to work at plants again. I have still nearly a month of vacation left.

Ever yours faithfully
Asa Gray

[*Asa Gray to C. W. Short*]

Cambridge, April 2, 1855.

My Dear Friend

I have lately taken hold and *finished* the distribution of the Berlandier plants, and have your set ready to be dispatched. As they will fill a good-sized box, I hesitate a little to forward by express—unless you so direct. Perhaps Mr. Griswold could give a good address and mode of forwarding by freight trains, saving much expense. I await your instructions.

I will have a copy made from my numbered list, which will give you the names mostly as far as the genus—and often species also,—which will afford you the aid you need. And very soon I hope to publish the

determinations &c as far as to the end of Compositae. Beyond this the numbers will be cited in the proposed continuation of my account of Tex-Mex. collections (Pl. Wright. &c &c)—which I hope to be working at again soon—parallel with rest of Flora vol. 2.

The distribution and now the arrangement and elaboration of my own set is now small labor,—but it is a useful work.

Sir Wm. Hooker lately wrote that he was to send a packet of seeds to me for you. They have not yet arrived,—probably will come a fortnight hence—

In great haste
Ever Yours most cordially
Asa Gray

[*George Engelmann to C. W. Short*]

St. Louis, April 12, 1855.

My Dear Doctor

I was delighted to see your well known handwriting again after so long an intermission. But I believe the silence was caused by me. Be it as it may you broke it in a most agreeable way by sending me that interesting collection of plants, some of them entirely new to me. My best thanks for them.

My leisure hours get more and more circumscribed, till I shall be able to break through, give up medicine and devote all my time to the "scientia amabilis." I would almost have said that I can not do anything in Botany now, had I not had Dr. [J. M.] Bigelow here who for the last four weeks studied the Cactaceae, collected by him with great zeal and perseverance in Capt [A. W.] Whipple's Railroad expedition. He had been surgeon to the Mex. Boundary Commission and had there made friend with these spiny fellows, and was well prepared for his last expedition 1853–54. He went up the Canadian and almost entirely under the 35 degree of latitude, and found there probably as many as 40 species of Cactaceae! Many of them, new.

I have come to the conviction that our western Opuntia is distinct from the eastern O. vulgaris which seems to grow only along the seacoast or at least only in the Atlantic States. I have traced our plant throughout Missouri and Arkansas and Illinois into Iowa and Wisconsin Westward it seems to be replaced by other nearly allied species. How far it spreads eastward I have no means of judging.

I can not find it mentioned in your published Catalogue but Riddell*

in his says: "sandy banks in Kentucky, & Illinois. Dr. Bigelow who lives in Lamartin Ohio has never seen it.

Elliott says there are probably 3 species in the southeastern States.

In a german work on Cactaceae I find it said that Nuttall established 3 species on plants found in *Kentucky*,

"*O. caespitosa*, prostrate, with obovate joints, very small red brown bristles and single long spines

"*O. mesacantha* prostrate, with suborbicular joints, red brown bristles and long brown single spines.

"*O. humifusa*, seems to be the same as one of the others."

I have provisionally adopted the name of *O. caespitosa* for the western *O. vulgaris*, and I found a texan plant, which seems to correspond with O. mesacantha. It has longer and more numerous bristles and dark brown stout spines.

But has really Nuttall established these species or perhaps Rafinesque and where may they be mentioned or described?†

I find the Opuntiae especially as difficult and as numerous as our Asters are.

Ever truly
Yours
G Engelmann

* John Leonard Riddell (1807–1865), physician and botanist, born in Leyden, Mass. Published *Synopsis of the Flora of the Western States* in 1835. In 1836 he became professor of chemistry in Medical College of Louisiana (now medical department of Tulane University). He compiled a catalogue of Louisiana plants, published in abridged form as *Catalogus Florae Ludovicianae* in New Orleans Med. and Surg. Journal, May, 1852. He contributed to the development of the binocular microscope.

† These are Rafinesque species, not Nuttall. Britton and Rose (*Cactaceae* 1: 127. 1919) consider them all synonyms of *O. opuntia* (L.) Karst.

[*Asa Gray to C. W. Short*]

Cambridge, 19th April, 1855.

My Dear Friend

Our late letters crossed. Last evening I got the small box from Hooker, and to-day, since my lectures, have unpacked it,—put the 11 live plants into a small box—and packed with your Berlandier set into a large box, which goes to-morrow by Adams Express—addressed,

as you desire, to *W. Allen Richardson, Esq.* Louisville, Kentucky.—I hope it will reach you promptly, with *the live* plants (of no great consequence) *alive*, and the seeds in good time.

I meant to have looked over the small parcel of plants you sent for names—and, after naming such as I can, return to you in this box. But I have not now a moment of time—college work, garden, and an article for Silliman occupy every moment. It must wait awhile. Some, I see, must be named by Dr. Torrey.

The box from Hooker—tho' duly marked "On his Majesty's Service" by some minunderstanding, was charged freight and commissions, etc. £ 1. 0. 4.—the bill sent to me by shipper, marked "Paid in Liverpool", therefore charged back to Hooker.

By next week's steamer I shall therefore direct a friend of mine in Dublin, who acts as small banker for me and keeps a balance in his hands from me, to pay this sum to Hooker by a post-office order.

I will take from you 1/3 of this. =	$1.67
of. charges from steamer etc.	.33
	$2.00
Sending box to Boston	.25
	$2.25

I will have the Express-man from Cambridge get a receipt from Adams & Co.—and enclose in this for the large box.

As soon as I can I will furnish you with names—as far as may be, of Berlandier's plants. They contain much rubbish, but some fair specimens and many good things. Yours truly as ever

Asa Gray

[*Alphonse DeCandolle to C. W. Short—April 25, 1855*]

Monsieur le Docteur

Permettez que je vous exprime sans intermédiaire ma reconnaissance et celle de M. Dunant, pour le cadeau que vous voulez bien autoriser le Dr. Gray à nous faire sur les plantes de Berlandier. Ce dernier est allé au Texas par les soins et aux frais de M. Dunant, de mon père et autres souscripteurs; il ne s'est pas trop bien conduit à leur égard, mais l'association a été liquidée par une perte finale et maintenant M. Dunant n'a rien a réclamer des heritiers de Berlandier, encore bien moins des personnes qui ont acheté de bonne foi des collections de lui. C'est

donc pure générosité de votre part de nous envoyer des doubles et je me fais un plaisir de vous le témoigner. M. Dunant vous aurait écrit si je ne m'etais offert pour tenir la plume et s'il n'etait en voyage depuis quelques mois pour motif de santé.

Le Dr. Gray me dit que vous aimez les autographes de botanistes. Je vous envoie ci-joints trois fragments des manuscrits de mon père et, ce qui est un peu plus difficile à trouver, sa signature complète. Il rédigeait toujours ses articles botanique sur des morceaux de papier quil fixait ensuite dans l'ordre adopté définitivement. Ceux-ci avaient été rédigés en vue du *Systema regni vegetabilis* et ont servi (en les abrégeant) à la redaction du *Prodromus*.

Je possède beaucoup de lettres et manuscrits de botanistes, mais jusqu'à present je n'ai pas en le loisir d'arranger la correspondance de mon père où se trouvent les plus intéressants. Si vous desirez des autographes vous pourriez me donner une liste des noms d'auteurs qui vous manquent et tôt ou tard, cette liste sous les yeux, je mettrais de côté ce que je trouverais dans mes papiers et dans ceux de mon père.

Agréez, Monsieur, l'assurance nouvelle de mes remerciements et de ma consideration distinguée.

Alph. deCandolle

Genève (Suisse) 25 Avril 1855.

[*Asa Gray to C. W. Short*]

Cambridge, May 2, 1855

My Dear Friend

I trust before this the box, by express, announced by my last letter has reached you—in good condition.

I have been very much occupied, in addition to College duties, &c—in writing an *Editorial* article for the July number of Silliman, on the Smithsonian Controversy—which, as we want to make it the *leader* for the July number has to be in hand early. It has been sent on to New Haven. When it appears I trust you will think it proper and seasonable.

At length, getting a little leisure, I have looked through your parcel of plants to be named, from Calif. &c &c—have named a good share of them, and put up the parcel to return to you.

I have also named and put into said parcel a few plants that you evidently wanted names for in the larger parcel intended for me. On the opposite page you will find my opinion on a few more such, of which I have retained the specimens.

Spring though late is opening pleasantly. Jeffersonia and Sanguinaria are just in blossom.

I am now going to name carefully all my Berlandier plants up to the end of Compositae and put away in Herbarium.

It is not worth while to send this parcel separately, by Express, so I will address it outside to Morton and Griswold, and leave it at Little & Brown's—to go in first case to Louisville.

By the way, you will be glad to know, that the late Mr. Brown (Little & Brown) left a legacy to purchase books on Nat. History to the amount of $5000—for our College Library—the books to be selected by the Prof. of Nat. History, i.e. by

Yours cordially
A. Gray

"Fraxinus A. & B." = F. Americana.
Euphorbia, Banks St. Lawrence = E. Helioscopia.
Coreopsis cult. for C. Drummondii, more like C. auriculata = *C. auriculata.*
Xyris, New Jersey = X. Caroliniana.
"Ceanothus azureus ? Cult. = Yes!
Cyperus Grayii? N. J. = Yes!
"Campanula, Montreal" = *C. rapunculoides.* Introduced.
"Oenothera speciosa? Texas" = O. sinuata.
Stout-umbelled, growing with Cicuta maculata. Long Branch, N. J. = *Cicuta maculata* as far as I can see.

[*Asa Gray to C. W. Short*]

Cambridge, May 21, 1855.

My Dear Friend

With your excellent ideas, and superalitively [sic] excellent practice about botanical specimens, I am not surprised that you should be grieved and indignant at Berlandier's poor stuff. But I am very glad you did not burn the plants up. Now I have more patience, being used to all sorts of rubbishy specimens. The whole collection of South Sea Exploring Expedition is scarcely any better. And there is a vast deal in Berlandier's collection which I am exceedingly glad to have, and much more that I must make room for in my herbm. in order to know to a surety what this or that number, distributed in several herbaria, is. But you are not bound to give them house room; and if they are too great eye-sores to you, don't commit them to the flames, but present

them to the herb. of the Academy of Nat. Sciences of Philadelphia. They will be very thankful for them, I know.

I see ample evidence that Berlandier was not only a lazy lout, but a great *scamp*, as you say. I find he used to collect a quantity of a plant all at one and the same time, and distribute only a part under one number—and afterward give the rest under another number—Sometimes the same stock was distributed and sold under 3 or 4 numbers!

I have determined the plants very successfully up to the earlier Leguminosae—and shall soon finish up to Composita inclusive. But just now my college work is onerous and pressing—leaving not much time for botanical investigation.

My article on the Smithsonian Institution will appear in the July number. I shall send you an extra copy.

The choice of the books on Mr. Brown's legacy was left to me on account of the name of my professorship,—tho, I teach no Natural History except Botany, including Vegetable Physiology.

I think I wrote you of the Hon. Miss Murray,* to whom I gave an introduction to you. I think by this time she has visited Louisville, and I hope you have seen her.

The *100 folio drawings* of 1st vol. Exploring Expedition Botany are all in engraver's hands at Washington. But there they get on slowly. Proofs of a large part were promised me long ago, but they do not come. They get on very slowly there.

Your check for $20 much overpaid any expense incurred by me on your account. Your next boxes or parcels for me to forward please send unpaid,—or give me any commission to execute for you—that in time I may use up the balance.

In usual—& indeed *unusual* haste,
Yours most cordially
Asa Gray

* Amelia M. Murray, who travelled in this country in 1854–55. Her published *Letters from the United States, Cuba and Canada* (G. P. Putnam and Co., 1856) express great sympathy for the South in the question of slavery.

[*George Engelmann to C. W. Short*]

St Louis, June 12, 1855.

My Dear Doctor

Your favor of May 13 has been in my hand some time; and I hope your plants have now reached Dr. Mead—I had them here some time before I could find an opportunity of sending them.

Your offer of Rafinesque's writings I thankfully accept; though I believe with you that the trouble of sifting the little good wheat from the mass of chaff is vastly greater than to go to work anew without paying any attention to him.—Agassiz however lately has paid more attention to his labors about fishes and seems to consider him quite sharp sighted, and ahead of his contemporaries. I fully agree in all you say about Nuttall—I find that implicit reliance can be placed on all he says—though his judgement may err.—I have never met with him—but have been told of his personal appearance as of great oddity—he is said to be very reserved, and unsocial.

You do me too great an honor in classing me with Carey, Sullivant and others—Though I confess that my desire would be to devote myself entirely to botany. What has become of Dr. Chapman?* He has not answered my letters since years. I do not know whether he is alive or dead, negligent only or does he not want to answer me?

How is it that in the rising generation we find no botanists—not even so far as I know, amateurs? or very few at best?

My best thanks are due you for the interesting Berlandier collection received through Prof Gray. Together with Lindheimer's, Gregg's and Wright's it goes far to complete the botany of the Rio Grande Valley.

I remain, my dear Sir
Yours faithfully
George Engelmann

* Alvin Wentworth Chapman (1809-1899), physician and botanist, was born in Massachusetts but spent most of his life in Florida. He was the author of *Flora of the Southern United States*, published in 1860 with later editions in 1883 and 1897. He furnished Torrey and Gray with many southern plants for their *Flora of North America*, and they named the genus *chapmannia* for this distinguished botanist.

[*George Ticknor to Asa Gray*]

Boston, June 18, 1855.

My dear Sir,

I have no objection whatever to permit a person, such as you describe Dr. Short to be, to have a copy of my Head of Sir Walter [Scott]; and, probably, I can give him one or two documents in relation to it, which will make him value it as a true likeness. But I am not ready to recommend any person as a suitable artist to copy it. I have inquired, and will inquire further; but as the whole value of the picture must depend on its faithfulness, I think it still more for Dr. Short's interest

than for that of anybody else, except my friend Leslie,* who painted the original, that the right person should be hit upon;—or at least a person who may be safely trusted. When it was painted thirty years ago, Leslie was anxious about this very thing, and Sir Walter desired that it might not be copied or engraved for a certain number of years,—7, I think,—lest it should interfere with artists in G. Britain, whom he was bound to favor. But that is thirty years ago, or nearly so much, and all those people, I suppose, are in their graves. I am quite free, therefore, to do as I like;—but I feel that I ought not to consent to the picture's being copied unless a suitable artist is proposed for it or I can find one. So much seems to be due to Leslie. So much, I think, your friend Dr. Short would desire.

Yrs. very truly,
Geo. Ticknor

Prof. Gray.

* Charles Robert Leslie, R. A. (1794–1859), born in London of American parents; came to Philadelphia in 1799; returned to England in 1811 but was again in America in 1833 as professor of art at West Point. In the fall of 1824 he visited Abbotsford and painted a portrait of Sir Walter Scott for Mr. Ticknor of Boston, a well known patron of arts and letters.

[*Asa Gray to C. W. Short*]

Cambridge, 21st June 1855.

My Dear Dr. Short,

I have yours of the 1st & 5th—the latter enclosing the letter for Nuttall which was duly forwarded by British mail.

When convenient, please send me some seed of the delicate *Collinsia verna*. It is long since I have seen it growing, and I have formerly tried in vain to get seeds of it.

As to yours of the 5th, about portrait of Sir Walter. What follows will explain the delay which has occurred in my reply.

As to Mr. Ticknor—a gentleman of fortune and great scholarly acquirement—predecessor of Longfellow as Prof. of Modern Languages & Literature here—author of History of Spanish Literature—etc—remember the lines

"Whom not to know argues one's self unknown."

I waited till I could go to Boston and prefer your request in person—But he was not at home when I called. So I wrote a letter to him. He evidently took some time to enquire about a painter, and his note, dated 18th, was not mailed till the 20th & reached me to-day.

I enclose it, for you to retain, if you wish.

Ames is now here, I think—perhaps the best painter—at least the best colorist—but he does not always hit likenessess.—So might not copy Sir Walter well. Mr. Ticknor would best know. If you will leave the choice in his hands—and drop a line, through me, to Mr. T. acknowledging his courtesy and commending it to his judgment, I will see him duly, and the thing shall not fail through any lack of diligence or attention on my part.

I am quite gratified to have you avail yourself of my services in all such ways.

By the way Hooker has returned my little remittance to refund the freight the steam packet company charged on his box to us,—and has blown up the said company for making a charge they had no right to (as I knew)—and for which they have begged his pardon. Hooker did not know that I was apprised of their having charged him freight. So I hold in my hands a large part of the sum I charged you—besides this balance—quite a little balance—so that I can pay little bills for you some time yet.

Did I send you a little photograph of myself—a copy on paper from a negative for which I sat for the Senior Class—as did all the Professors, etc. I can send you a copy if you wish—and also from a larger one, probably—much finer as a picture, and larger, but Mrs. Gray thinks not so good a likeness. You can have your choice—i. e. you can have both. The little one I can send in a letter, if I have not already.

With Agassiz' Circular,* I send the private one he sent me. The influential men are taking it up with spirit in Boston—and it will doubtless *go*.

If you care to subscribe send through me.

Still very busy—& this summer must be still more so, if I would do half of what I ought & *must*. Ever Yours

Asa Gray

* Prospectus of his *Contributions to the Natural History of the United States*.

[*Charles Daubeny* to Asa Gray* [?]]

Oxford, July 27th, 1855.

My dear Sir

I have been very negligent in not noticing sooner your kind present of several Botanical pamphlets—and likewise the packets of plants from Dr. Short of Kentucky which came to me through your hands.

The latter are indeed for the most part Duplicates, but nevertheless

they will in many cases take the place of those we had before as his [are] better specimens.

I do not know what class of plants would be acceptable to Dr. Short, whether British, European, or Asiatic. If I knew perhaps I might be able to send him something in return from our Duplicates, which it would give me much pleasure to do. I take the opportunity of sending you two little Pamphlets of my own, one of which, on the Fungus theory of Cholera, deserves any merit it may have from following the footsteps of your distinguished countryman Dr. Mitchell.† The other points out a line of research which perhaps may be worth following up. My method is, I am persuaded, the only certain method of detecting minute portions of phosphoric acid when existing along with other ingredients in a rock.

Have you seen Dr. Hooker's Flora Indica, or the beautiful work he has edited of Indian plants drawn by the late Mr. Cathcart? I hope if you ever visit us again you will find natural history "looking up." The University of Oxford has voted £30,000 for a new Museum and the Building is now in progress. Remember me to Professor Silliman and believe me

very truly yrs
Charles Daubeny

* Charles Giles Bridle Daubeny (1795-1867), English chemist, botanist, and geologist. From 1822-1855 he was professor of chemistry at Oxford University, and during part of the time taught botany.

† John Kearsley Mitchell (1793-1858), a Philadelphia physician who wrote *On the crytogamous origin of malarious and epidemic fevers* (Philadelphia, 1849). He was the father of the distinguished physician and author, S. Weir Mitchell.

[*George Engelmann to C. W. Short*]

St. Louis, Octob. 13, 1855.

My dear Doctor

I hope you will not think too hard of me for my neglect in acknowledging the receipt of those books of Rafinesque's. They have been in my hands for some time and I was a good deal interested in looking through them; not so much I must confess at the amount of research and knowledge displayed in them as at the barefaced impudence with which he urges his decisions and assails better men. The criticism on Nuttall's Genera is particularly rich!

The whole however is of no inconsiderable interest to me as a docu-

ment appertaining to the history of the development of the Natural Sciences in this country—and of the occasional perverseness of the human mind!!

I am well occupied with Cactaceae, and as Government is going to pay the expenses I am enabled to furnish numerous plates (mostly details).

Your Catalogues I believe do not mention Opuntia, but Riddell says: O. vulgaris on sandy banks of Kentucky River, and Rafinesque mentions Kentucky & Tennessee as localities.

Is Opuntia cultivated in your gardens? Here I see it very frequently in gardens and on windows, walls etc in old pots, boxes, tinpans etc much like Sempervivum in many european towns or villages.

But our and probably all the western plants from Kentucky to the far west (certainly Nebraska, perhaps New Mexico) differs from the the N Jersey and Virginia plant, which seems to belong to the Eastern slope exclusively and is the O. vulgaris of European Gardens. Ours has larger joints, of deeper green, larger areolae with more numerous and longer and brown bristles, and mostly numerous spines; also difference in seeds.—The leaf in the young growing plant (May and June) is also very different, much longer, slender, patulous.—Do you cultivate Cacti?

Very truly yours
G Engelmann

[*Asa Gray to C. W. Short*]

Cambridge, 13' Oct. 1855.

My Dear Friend

Received (as better than none) a short and hurried line, to inform you of my safe return day before yesterday by the S. S. Canada, and to thank you for your very kind letter to my dear wife during my absence.

I was gone only 6 weeks and a day,—had two prosperous and rather short voyages. I thank God, found young Loring* convalescent,—brought him home in very good condition. Had 11 days in Paris, a week in England. Missed dear friends I wished to see,—such as Joe Hooker—but saw and enjoyed others, among them good Sir Wm. and Bentham who came down from the country to meet me, and the venerable *R. Brown*, whom doubtless I never shall see again in the flesh.—Also saw Boott†, etc.

Sir Wm. Hooker asks much after you, and longs to see you.—(I am

to get *your photograph* for him when I can). He bears no marks of age except in whitened hair, his form is as straight and his mind and body active as ever. His portrait painted for Linn. Society is now being engraved from. He will send you a copy. I took to him the last and most wretched part of the Berlandier collection. He insists that it is *very valuable* to have.

The fact is the voyage is nothing now. (Behold how easily I have made it!) and you must run over next spring, and visit Hooker, and see *Kew Gardens*—and delight Hooker's heart.

We could not get into the steamer of 13th Oct.—so were obliged to return 2 weeks earlier than I wished. But the time is very valuable here, and I had not sufficient excuse, on Loring's part, for staying longer.

The sad, very sad thing, on my return, is to learn the death of my dear friend *Mrs. Torrey*,—a deep bereavement to Dr. Torrey, I can hardly bear to think of it,—except when we think how good she was, how ripe for heaven, beyond almost any one I knew.

My wife sends her best regards—Ever thine

A. Gray

* A brother of Dr. Gray's wife.

† Francis Boott (1792–1863), physician and botanist, was born in Boston, Mass., but spent most of his life in London. His published botanical work was to great extent on the Genus *Carex*.

[*Asa Gray to C. W. Short*]

Cambridge, Oct. 26/55.

My Dear Short,

I am very sorry to learn you have been ill, but hope to hear good news of you in rapid convalescence. You should *migrate* in summer.

As to Holton's* N. Grenada plants, a full set is to go to Hooker,—and Hooker kindly promised me that as they go into his herbarium his curator shall record the names as far and as well as he can make them out. Perhaps Bentham will help a little. This you will be glad to know if you take a set,—as I will report all the names I get to you.

My object in this hurried line is to say that I am now preparing early part of Manual, new ed. for the printer, and I should like to feel more sure about the limits of some plants. I think I told you, that, to make a good botanico-geographical line, I have concluded to take in *Kentucky* and Virginia.

Now I do not possess your Catalogue of Kentucky Plants—I have only the 4th supplement. I presume the original Catalogue, etc.—is not now to be had. I must borrow Torrey's copy.

I see Riddell cites you for *Magnolia macrophylla* and *M. cordata*† in Kentucky.

The former I should rather expect. Pray tell me if this is so, as in that case I must take them in.

Any notes that occur to you as to Kentucky plants I might overlook will oblige me much.

At present, think only of those that come in the early part of the book.

Ever Yours cordially

A. Gray

P. S.

Alph. DeCandollé has sent me a duplicate of a good lithograph of him—to be given to whom I like (Torrey is supplied)—and he mentions your name, and says he will be glad you should have it if you care for it. I will *roll* it and send by mail.

Have you the fine *mezzotint* engraving of his father?

A. G.

* Issac F. Holton (1813–1874), a physician, professor of natural science in Vermont, and author of *New Granada, Twenty Months in the Andes* (1857).

† *Magnolia cordata,* a rare species, is now known to occur only from Alabama to North Carolina.

[*Asa Gray to C. W. Short*]

Cambridge, 9' Nov. 1855.

Dear Dr. Short,

Without waiting for the arrival of the pamphlets, which you are very kind to send me and which will doubtless reach me in a day or two, I add a mem. or two called for by your favor of the 3rd inst.

Cardamine Ludoviciana. Where published as "*C. praecox,* Raf."

"Arabis hispidula = Draba muralis" [= nemorosa] Where published under former name? Surely introduced in Barrens of Ky? But a queer place for a plant nowhere else intro.—Or is it indigenous.

Leavenworthia. I have an idea that both species of Torrey are one,—and the plant has white or rose-colored petals yellow only at the base says Hatch, and so it is in the flower that has appeared from seed I raised. Did you see them yourself in blossom? Have *you* evidence of 2 species? What color petals?

*Vesicaria Shortii**. I possess a portion of the plant you gave Dr. Torrey. The characters of the species are not yet known, as to the fruit. Our specimen having only unfructified ovaries,—at least no grown pods. Have you any? And can you send one?

This is becoming the more interesting, since Lesquereux's discovery, in E. Tennessee, of *another* species; which however, is rather an *Alyssum.* I send you a small specimen. This can be no form of your plant, V. Shortii??

"Viola sororia." What is this? V. cucullata?

"Stellaria palustris. Marshes about Louisville" What is this? S. aquatica?

I will send the portrait of Alph. DeCandolle as soon as I get hold of a roller to roll it on.

I hope this will find you in more confirmed health, and free from cough. I trust the *infirmities* of age are what you need not take note of for a long while yet.

In a few days, viz. on the 18th inst. I shall reach 45,—after which—except when I forget,—I propose no longer to call myself a young man—yet I feel as young and active—and almost as ardent—as at 25.

Ever Yours cordially

Asa Gray

* Now *Lesquerella globosa* in Gray, 7th ed.

[*Asa Gray to C. W. Short*]

Cambridge, Dec 3d, 1855.

Dear Short

What is the plant we in the *Flora* have called *Hypericum rosmarinifolium* Lexington, *Short.* I have no specimen. (Could you send me a few fragments). I suspect it is H. prolificum var.

Leavenworthia. On the strength of the color of the petals I have kept them apart—the 2 species—in the Manual. I have L. Michauxii growing,—the plant kept in the greenhouse is flowering a little now. Its flowers are whitish, yet it has the foliage and the manifest style of L. aurea. After looking at all your specimens, and Torrey's, I see that the length of the style is inconstant, and L. aurea is sometimes flowered. So I fear greatly for the two species.

I have *cabbaged* a little out of your herb.—as these belong to the *Cabbage order,*—not much.

Dec. 12. Evening.

There, Dear Dr.

I have only now finished—by snatches the little parcel of nice plants you sent me in the box with Cruciferae—and report the result.

The Cruciferae I have looked over, and annotated when needed—some time ago—along with the proofs of *Manual* in that family.

I have been more pressed for time than almost ever before: I am worked to the bone—(Yet health and spirits never better)—preparing copy with one hand for Manual and reading proofs—and with the other working in haste for Torrey on Whipple's Report, &c &c—and doing lots of other things—which I have not time even to write an enumeration of.

I waited till I could send you these little notes and announce the return of your Cruciferae, before I replied to some matters in your favor of the 19th Nov. which I have kept by me till now.

Lesquereux discovered the Crucifer I sent near Nashville.—I call it *Vesicaria? Lesquereuxii.* He is a Swiss,—a very good man—unfortunately now very deaf—and a keen Muscologist as well as general botanist—He has long worked with our friend Sullivant, and resides at Columbus, Ohio.

Vesicaria Shortii is distinct from any thing else I know.

Dr. A. W. Chapman resides at Ap[a]lachicola, Florida, the very place for your headquarters if you go to Florida. I lately had a letter from him for a wonder. No other botanist in those parts.

Now for your favor of Dec. 6—this day received.

You are quite right in applying to me. Always apply to a busy man, too, if you want anything attended to.

Other matters as well will take me into Boston tomorrow. I will take a sheet from your Cruciferae for sample—and match it as well as I can at the paper warehouse where I deal, and send you the 2 reams by Express.

Perhaps I will have your *Cruciferae* enclosed in the same box. I will have it cut to size.—DeCandolle's portrait to go with the Cruciferae. I have not a copy now of the Providence Photograph but will send for one.

I am sorry about Holton's specimens. He had to collect and carry his plants on horseback, etc. etc.

I shall dispatch you another line, probably by the time you have fairly deciphered, or guessed at, these scrawls

Ever Yours cordially

A Gray

With thanks and best regards from Mrs. Gray

[Elias Durand to C. W. Short]

Mar. 25, 1856.

Prof. C. W. Short, Louisville.
Dear Sir,

I have received with great pleasure your favor dated 12th inst. Although not personnally acquainted with you, your name and beautiful botanical specimens have been long familiar to me; I am in fact the same who once used to correspond with your friend and colleague—Dr. Peter. Arrived in this country since 1816, as an exploring young botanist, my position was changed by circumstances; my purse proved too shallow to live on the scent and admiration of flowers and, instead of continuing my courtship to sweet Miss Flora, I had to closet myself in a drug store, amidst the perfumes of Assafoetida, Galbanum and Valerian, losing my health and cheerfulness.

I had a family, and this family, unlike those of father Jussieu, wanting bread and clothing, I gave up my botanical studies to attend faithfully to my professional and parental duties. As one says: Labor improbus omnia vincit, I succeeded of late in throwing off the pharmaceutical harness and to return to my first love! But it was too late—I felt rusty, decrepit, unfit, although still loving and ambitious, as you may see by my poor productions. They are not owing, believe me, to an excess of confidence, but to an excess of local pride. Since the disappearance of Schweinitz, Pickering, Nuttall from Philadelphia, I remain the only botanist of the Academy of Nat. Sciences, that has leisure and disposition to work, and I could not suffer that plants presented to our Academy should be sent out from Philadelphia, to be described elsewhere.

I am a hard working man. I have been these two years occupied, four hours a day, in arranging a North American herbarium for the Academy. I am now finishing a third paper on the polar plants collected by Dr. Kane* in his two expeditions, and will soon begin the examination of Sta. Fé plants collected by a Dr. Henry of the U. S. Army. I hope I will show improvement and the justness of the old adage "Vires acquirit eundo".

I accept with great pleasure the specimens of Oenothera you offer to me. Those collected by Mr. Pratten were very poor and incomplete—the few I had, have been left in the Academy herbarium and I have not a single one in mine. The var. of Oe. Lindleyi has proved to be a new species and I think the handsomest of all Oenotherae. It was much the

fault of our friend Gray, if I did not make it at once a new species, as it really is. Most probably I shall have to call upon your generosity for some of your new species; but at present I could not say what is wanting—it will be only when I, again, look over the herbarium I am now making for the Academy, that I shall be able to take notes. There are in it [a] great many undescribed species, especially among those collected by Maj. Leconte in the Southern States. It will be a good harvest for me, if I live.

With great respect, my dear Sir, I remain your humble servant

E. Durand

Phil. March 25th 1856

* Elisha Kent Kane (1820–1857), born in Philadelphia, naval officer, physician, explorer on route to north pole, author of *Arctic Explorations: The Second Grinnell Expedition in Search of Sir John Franklin, in the Years 1853, '54, '55* (2 vols., 1856).

[*Asa Gray to C. W. Short*]

Cambridge, Oct. 10, 1856.

My Dear Dr. Short,

I am very sorry that you should have returned to Kentucky without my having a chance to meet you: but am pleased to hear of your recovered health. You should have summered *down east* here with us.

Engelmann has been here now for a month or more, working like a good fellow, at Cacti first, now at *Euphorbia*. He will not get off for Europe before November certainly,—though he works hard, and constantly.

The likeness of dear Hooker is a flattered one, certainly,—not that he is not a very fine looking man. He is well pleased you should have it, and has supplied Greene, on the spot. By the way, Hooker is neither a Scotchman nor a Baronet. He was born in England—in Norfolk, I believe,—tho. his father was originally from the S. of England, I think, and only went to Scotland on being appointed Regius Professor at Glasgow. He had already married Dawson Turner's daughter. Before this he had made his trip to Iceland, as a young man, collected there,—was interrupted by a curious bit of a revolution there got up by a remarkable filibuster,—the ship he returned in was set on fire—and all his collections were burned up.—It is an interesting book, that of Hooker's, and I advise you to read it, if you get hold of it.

Wm. IV made him a Knight of the Hanoverian order,—which gratified

Lady Hooker. A title to transmit to descendants is more than his only surviving son, Dr. Hooker, would care for (rather despising such things) without a fortune to sustain it,—and Hooker will barely leave his family comfortable, but no fortune to make anyone independent. His son will succeed him at Kew, however, if he survives his father. Long may both flourish.

I am not surprised at what you say of Herbm. at Acad. Philad.

Would you give me leave, on my own responsibility, to sound Prof. Henry, and see whether they would like to take your herbarium on the conditions it would be best to affix, to secure it in perfect preservation. I should have cases made in a manner I could explain, with battened doors shutting always tight, etc.

If there should be any doubt about it there, and no proper and safe place offer in your own State for so valuable an herbarium, I now think I may be able to secure a proper place here. There is an old accumulating fund for building an Anatomical Museum, left by Boylston, and it is now being filled [fitted] up by subscription of a few thousand dollars—for our museum of comparative anatomy, etc. When the new building is erected the small detached building now used for the Museum, and above for Wyman* and my lecture-room, will be vacated, I am going to apply for it, and for the old cases all fitted up in it, for a Museum of Vegetable Matters and products, on the plan of Hooker's etc.—and shall probably get it. Then I must try to lay a good foundation for a Cabinet of woods, fruits, fibres, etc.—etc.—and, as the building is detached and brick, it will be the safest place for finally depositing my herbm. when I am done with it. For here at the Garden we are much too poor to get a detached fire-proof room to keep the herbarium in. And if we ever improve our small fund by subscription or any other way, it will all be wanted for the garden itself. So that, if I can secure the small building 2 or 3 years hence, I shall probably arrange to have my herbm. go down there for its final rest, and yours shall go with it as a separate herbarium, if you can make no better disposition of it. But I think the Smithsonian would take proper care of it.

I will add seeds of *Pentstemon Torreyi.*

Your Helianthus doronicoides began to flower a few weeks ago. Engelmann and I compared the plants and the tubers with *H. tuberosus*, and we are convinced they are the *same species.*—So there is an important point settled. I shall compare them again carefully another season if I live. Is the plant you sent me roots of just about the same as the doronicoides so common wild about you?

As to Nuttall, he is a truthful man, no doubt, and an interesting one. If I ever spoke disrespectfully of him (as I may have) I was to blame. His Genera was an admirable work for its day, and much the best thing he ever did. His later works and memoirs fell off in character, sound judgement, and conscientiousness—very much indeed, and there are things about them that would tempt one who followed closely after him to compare him with Rafinesque; but it would not be just. If Nuttall had kept up to the promise of *Genera N. Amer. Plants* he would have been the great expounder of American botany.

I can soon send you family or generic determinations of enough of Fendler's Venezuela collections to be of much use to you. Remind me again if I neglect it too long. A quantity are to be distributed into my herbm. first, and I have no chance to do it yet. I lately had an interesting letter from Fendler.

Manual has been out 5 or 6 weeks. I though you had got it from New York, or I should have sent you a copy. Had I not better do it now?, and send with it a copy of Sullivant's extra issue of the Mosses, large paper, proof plates—a very pretty volume, just out of the binders' hands, yesterday. Only Sullivant I suppose will insist upon sending you a copy.

Carey—incited by dear Boott, gave me some notes on Carices for new edition. Said he could do no more till the days got longer, so that he could examine plants by daylight out of business hours. He will probably not do much more in Botany, but keeps up the love.

It fortunately happens that I have no *college* duties this year at this season. But it is quite impossible to be absent from here. I am now putting a new fence round the garden—in place of one which has most of it been in wear for near 50 years! I have raised 1000 dollars by subscription to do it with,—as nothing could be spared from our income of $800 or $900 a year for that purpose—and I have to see to it and make it go as far as I can. But next fall, if we live, and I am equally lucky in the arrangement of college studies, and make such progress in work on hand that I feel I have any honest right to a holiday, I hope my wife and I may make a trip west, and come and see you. We should like it of all things. God preserve you all meanwhile. This is a long letter for me.

Ever Yours cordially ·
Asa Gray.

* Jeffries Wyman (1814–1874), professor of anatomy in Harvard College and first curator of the Archaeological Museum there.

[*Elias Durand to C. W. Short—Mar. 17, 1857*]

Prof. C. W. Short, Louisville, Ky.
Dear Sir,

Your favor by Prof. Richardson was received a few days ago. Urgent occupations and indisposition have prevented me from returning his visit, before his departure for Louisville, where he told me he was shortly to accompany his lady. I will be happy to cultivate Dr. R.'s acquaintance, when he returns to Philadelphia and is disengaged from the troubles attending a removal to a new abode. I hope the presence of your daughter in our city may dispose you altogether to come and settle here.

You ask me, dear sir, if I possess a suite of Berlandier's collections in Texas and Mexico? Helas! no, and I regret exceedingly not to have any. A particular friend of his had given me a letter for him, and I was ready to open a correspondence wit him, when I heard of his death. If I desire some of his duplicates, it is more with the view to fill up the valuable herbarium Boreali-Americanum of the Academy and to replace in my own what I have taken from it to enrich the Academy herbarium (not less than 1800). Of course, any specimens you can spare, from the far western regions, will be very thankfully received.

I sent you, a few days ago, a biographical notice of the late François Michaux. My materials were authentic and all obtained here. I had written to his friend, Mr. Vilmorin, to ask him some information; but, in seven pages, I could find nothing to add to my manuscript, except the dates of his birth and death; all the other details were known to me, or very inaccurate. Seeing that they knew in Paris less than we know here about him, I have sent them a translation with more ample details than I could give in a discourse.

With great respect, my dear Sir, I remain your humble servant

E. Durand

116, South 9th St.

If Prof. Peter is still in Louisville, Please remember me to him.

Philadelphia, March 17th, 1857.

[*August Fendler to Asa Gray*]

Caracas, July 16th. 1858.

Professor Asa Gray. M.D.
Dear Sir

Your kind favor of Decbr. 26th reached me in due time while passing

through the town of Victoria on a botanical excursion to a new region of the mountains.

I am very sorry to learn that you as well as Dr. Short and some of your other friends sustained such heavy losses by the disastrous bank failures and the commercial crisis of last fall. Here in Venezuela we have no banks at all, and therefore no bank failures. A new failures of commercial houses have however occurred in consequence of the above pressure.

With regard to progress of the country, political affairs and business in general, Venezuela may be said to be in a miserable condition; and people here, even the natives, acknowledge freely, that without the importations of Indian corn, beans, flour, wheat and other products from the United States, many of the inhabitants would have to die of starvation. Petty revolutions follow each other in quick succession, press the field-labourers into military service, take by force the horses and mules of the planter, prostrate agriculture and commerce, and ruin the prosperity of the country. Ever since my return from the States, two years ago, provisions have kept up at famine prices. This is the chief cause which made me leave Colonia Tovar, to try my fortune in Caracas. For since my last letter to you the price of Indian corn rose to such a height at the Colony, that people there did not sell the little barley they had, but kept it for bread instead of maize. As soon as I found that I could get no barley, I had to give up the idea of brewing beér at the Colony. I made several botanical excursions, arranged and distributed all my plants into sets, packed them in boxes ready for exportation, and made preparations to sell my little farm and to move to Caracas.

On the 6th of June I left Colonia Tovar, never perhaps to see it again. With a heavy heart I parted from the little cabin and its environs, which I had taken some trouble to improve by changing a waste place into a terraced little garden of roses, Fuchsias, plantains and apple trees. All, including some patches of potatoes, went for the sum of 66 Dollars. Such is the regard and taste for improvement in this country. The cost of transportation of my boxes and other luggage from Colonia to Caracas amounted to 40 Dollars.

The beer I had brewed at the Colony I took along to Caracas. Before I could get a house and bottles to bottle it, another fort-night passed away. The beer had remained in barrels for three months in the Colony, had been on the road exposed to the sun for two days, and then remained a fortnight more in Caracas before it could be bottled. All this it had stood very well without spoiling in the least. On the 27th of June I

opened a beer-house. At first only a few persons came to try the beer, pronounced it to be excellent, and soon the call for it was such, that in less than a fortnight all was sold. I must own, that at times I felt rather flat to see myself as a host of a beer-house surrounded by a crowd of noisy beer-drinkers. I tried however to keep up courage by the thought: that in giving to the public a wholesome, nourishing, unadulterated beverage, I might perhaps be instrumental to diminish their taste for strong liquors, such as the miserable stuff mixed with poisonous drugs, which is sold here under the name of brandy. The rapid sale of my beer spoke for itself. When all was sold people regretted they could get no more.

My expenses here are very heavy. I have to pay 20 Dollars house-rent a month, and the other current expenses for my brother and myself are very high indeed, so that without carrying the business on uninterrupted and on a large scale I can not make much headway. Barley there is none; the little I have on hand will soon be worked up, and before I can get some from the States the brewing business will be once more interrupted.

I am therefore somewhat inclined to go back to the United States, the country I love most in spite of its excessive climate. I have tasted sufficiently the charms of solitude for four years, and now I long to return once more to enlightened communities, to move within the spheres of an intelligent and enterprizing people, and to draw nearer to the broad light of civilization and learning that radiates through the *land of progress*. The balmly air, the perfume of flowers, the aspect of a tropical sky with all its host of brilliant constellations, even the stately palm and arborescent Fern are to an Americanized citizen, when in search of a prosperous home, no equivalents against the grand sight of a free people in its onward march to civilization and national greatness, as exhibited in the United States. The care for health alone keeps me yet lingering about the salubrious mountain-valleys of Venezuela.

I have hitherto delayed to send my collections of plants, because of going to the States myself. I can take better care of them than by leaving them to the tender mercies of a ship's captain.

In Decbr. last I received a letter from Mr. Thomas Moore of the Chelsea Botanic Garden in which he says: That he makes the Ferns his special study, is at present engaged in writing an Index Filicum, has quoted many of my numbers from Sir W. Hooker's Herbarium, and should like very much to possess the plants himself. He therefore wishes to buy as complete a set of ferns as possible.

I also received a letter from Dr. Engelmann, who writes that Prof. Mettenius of Leipsick wishes a most complete set of Ferns and Director Schott of Schoenbrunn dried and living Aroideae.

You will probably soon hear from me again. Please remember me kindly to Mrs. Gray and Dr. Short.

I remain

Respectfully and cordially Yours
A. Fendler.

[*Wm. Darlington to C. W. Short*]

West Chester, Penna, July 13. 1859.

My dear Sir,

Your obliging favor of the 6th inst. reached me on the 11th, and on the same evening Adams' Express brought me your *second* remittance of Specimens, for our Herbarium,—for which our Institution is deeply your debtor, and you will therefore please accept our grateful acknowledgements. The specimens are in excellent condition,—very much in the style of those with which you often favored us, in former years. I have looked over both parcels, and find in the first one *155 species*, which are *new acquisitions* to our collection; and in the last one, I find *45 new additions*,— so that, beside the *new* acquisitions (of some 200 species), there are a large number of most interesting duplicates,—many of which will serve to replace those which are less perfect, or have been preyed upon by insects.

Our Herbarium, now, contains near eight thousand species—arranged according to Endlicher's *Genera*,—and catalogued so that a visitor can see at a glance what we have; and, by means of the classification, any species named in the Catalogue can be promptly exhibited, when asked for. I commenced (a few years since) a plan of labelling the specimens on tickets large enough to contain all the *synonyms* given in the books; and it is curious to observe how well the several *specific names* often serve to describe, or indicate, the features of the plants, thus variously named, by different Authors. This mode of labelling being a pretty big job, and somewhat tedious,—I did not get more than half through with the project; and probably shall never finish it: but it is at once an interesting and useful illustration of the specimens.

I am very sensible of your good wishes, in relation to my continuance, here; but I feel that I have no claim, nor any expectation, to be indulged with as many years of active life, and clear intellect, as were vouchsafed to him whom Humboldt styled the "facile Princeps Botanicorum."

Robert Brown had *nine years* the start of me—and got a whole century ahead of all such small fry. I completed my 77 years, on the 28th day of last April. I think Sir William Hooker is about two years my junior; and I trust he may be spared, at least, to reach the age permitted to Mr. Brown. There is something very pleasant in contemplating the green old age attained by such bright ornaments of our race, as Brown, Humboldt, & Hooker.

I am very well satisfied with the Edition of my Agricultural Botany, as revised by *Mr. Thurber** (I believe he does not claim the title of *Doctor*). He is a very respectable Botanist,—and seems to be a judicious Editor. I corresponded with him, formerly,—but never met him until he called on me, about a year ago.

You are very kind—as well as complimentary—to suggest such a work, for me, as the Biography of American Botanists. If I were younger, and possessed of the requisite materials, it would afford me a great pleasure to labor in such a field. It is, however, quite out of the question, with me, now. I am not only destitute of *materials* for such a work,—but am conscious of a kind of lethargic habitude, which has overtaken me—with a strong and increasing disposition to *procrastinate* (think of *procrastination*, at 77!) every thing like a task. But I am happy to inform you, that an accomplished Lady of my acquaintance has been engaged for some time, in a work quite germain to that of which you speak; and I feel great confidence in her ability to do justice to the undertaking. The Lady is Mrs. Isabella James (neé Batchelder, of Cambridge, near Boston,) wife of Thomas P. James Esqr. of Philadelphia, long known as the efficient Secretary of the Penna. Horticultural Society, and quite an Expert—like Mr. Sullivant, of Ohio—in Bryology, or the Natural History of the Mosses. He furnished the Mosses for the last Edition of my Chester County Flora. Mrs. James has devised an elegant Tribute to the memory of the Botanists (especially those who have distinguished themselves in American Botany). She has taken the idea from the famous Palace, or Temple, erected on the banks of the Danube, in illustration, or commemoration, of the Scandinavian Mythology,—known as the Valhalla; and she proposes to intitle the work, "Flora's Valhalla". The volume is to contain a neat *Biographical Sketch* of each Botanist deemed worthy of a niche in The Temple,—illustrated, where practicable, by an engraved *Portrait*—a view of his *Birthplace*, or favorite *residence*,—a *figure of the Plant* (if any) dedicated to him,—and a *fac simile* of an *autograph Letter*. Such a memorial of the votaries of *Flora*, appropriately executed, in a handsome quarto volume, would tell the whole story,—make a beautiful

and desirable addition to a centre table, in the Parlor of every family claiming kindred with the names thus preserved,—and indeed for all persons imbued with a particle of taste for "the amiable Science,"—or animated by a becoming regard for departed Merit.

I have exhorted Mrs. James to persevere with this laudable Enterprise,—and she is now actively engaged in the work. I have furnished all the aid in my power (such as facts, dates, & autograph Letters, &c.),—and she has collected a goodly quantity of biographical material.

If the project shall find favor with a public-spirited Bookseller, and be completed (though I cannot expect to see it),—I shall rejoice in the contemplation of the anticipated achievement. If you sympathize with it, you can, no doubt, contribute valuable aid; & I am sure Mrs. J. will be thankful for it. Having now filled my paper,—most probably exhausted your patience,—I beg you to believe me ever your very sincere and oft-obliged Friend,

Wm Darlington

Dr. C. W. Short,
near Louisville,
Kentucky

* George Thurber (1821-1890), botanist and author, born in Providence, R. I., served as botanist, quartermaster, etc , on the survey of the Mexican boundary line in 1850 and for several years collected plants along the Mexican border. He taught botany and horticulture at Michigan State Agricultural College from 1859-1863, and then returned to New York and became editor of the American Agriculturist.

[*John Torrey to C. W. Short*]

New York, Jany. 19th 1860.

My dear Sir,

I have allowed too long a time to elapse before answering your letter—and yet there is scarcely a day that you are not in my thoughts. Various cares have pressed upon me, and calls (which seem important when they occur) are increasing in number—so that for several months my correspondence has been greatly interrupted.

You speak in flattering terms of the Botany of the Mexican Boundary Report; but regret (as none do more than the authors) that opportunity was not given to revise the work as it went through the press. You know how it generally is with public printing; especially that done for Congress. The lucky fellow who gets the fat job, cares for nothing but to receive his money in the shortest possible time—and so he runs the

work through with rail-road speed. Remonstrances and coaxing have but little effect. The best that can be done is to get up a copious list of errata if they will allow this, or, have some extra copies struck off for actual botanists—and make your own list of errors to accompany what you distribute.

I spoke to Mr. Thurber about the set of his plants that he promised you. He greatly regrets that for some year or more he has been obliged to work so hard on other matters to get his daily bread, that it has not been in his power to select the specimens. He hopes however, ere long, to fulfil his promise. You are aware, perhaps, that more than a year ago, he was dismissed from the Assay Office for not complying with a demand made that he thought compromised his political independence. He has very recently been asked if he would accept the place of Professor of Botany in the State Agricultural College of Michigan,—and I believe that he has conditionally assented. He is an excellent botanist, & a very good chemist. I hope he will be chosen. Did I inform you that he was engaged in preparing, under the auspices of the Smithsonian Institution, a general Catalogue of all the plants enumerated in every book & report, as growing west of Mississippi River? Exact references to each work will be given—and thus a great deal of labor will be saved to working botanists. Mr. Thurber will refer to the numbers under which the different collections have been distributed.

If you wish to know at once the names of any Wright's, Berlandier's, Fendler's, or Lindheimer's plants, and will furnish me with a list of them, I may be able to give the names of many—and Dr. Gray will aid in the matter. It will be well, when you know the family or genus, to indicate it—which will save time in looking up the plants, as most of them are distributed in our herbaria.

I have sympathised with you, my dear Sir, in the various losses you have suffered: and only hope that you may be so "exercised by them," that they shall "yeald the peaceable fruits of righteousness". Afflictions are often grievous to bear,—but we shall some day admit, that they were no more numerous nor lasting than our best interests required.

If you wish to submit your Salices to Andersson,* Dr. Gray will forward them to that zealous botanist—and then they will be named by the highest authority in the willow line. With sincere friendship,

I remain, as ever, yours,

John Torrey

C. W. Short M. D.

* Nils Johan Andersson (1821–1880), botanist of Stockholm, Sweden, who wrote *Salices boreali-americanae, a Synopsis of North American Willows,* Cambridge, 1858.

[*Asa Gray to William Short*]

Botanic Garden, Cambridge,
November 14th, 1863.

To Wm. Short, Esq.
My Dear Sir

I duly received your favor of the 3rd inst. I had already been making the needful inquiries, and I am now perfectly satisfied with the result of them. It is so long since I have been at Philadelphia that I had forgotten that they had of late years at the Academy assigned a good and spacious apartment exclusively to their herbaria, and have it well fitted for use.

I enclose to you a recent letter from my good old friend, the head of the Botanical Committee of the Academy, with whom I have privately corresponded. He writes better French than English, but his language is easily made out.

I recommend, therefore, with perfect confidence that the Family present the herbarium to the Academy of Natural Sciences, Philadelphia, to be held by that Society under the conditions prescribed in Dr. Short's will, one of which, I believe, is that the herbarium is to be preserved as a separate herbarium, i. e. not to be ever incorporated with any other herbarium, nor any other with it.

I would add also to the donation all the unassorted collections and bundles, and provide that all specimens wanted to supply the herbarium shall be selected and added to the herbarium, on paper similar to that used by Dr. Short, giving them leave to use the residue for general purposes of exchange or other useful distribution among botanists, as the Botanical Committee of the Academy shall deem most advantageous for the advancement of Botany.

Whatever paper for the herbarium is left on hand—both the *white* for species, and the *buff*, for genus covers, should go with the herbarium, where it will be wanted in incorporating the unassorted recent accessions.

Thus, I think the intentions and desires of your lamented Father will be quite as well secured as if the Smithsonian Institution had accepted the trust. The Academy at Philadelphia is one of the oldest, best-endowed, and most trusty of our institutions, and I have full confidence in its faithful performance of what it undertakes.

I wish I saw my way for the future as clearly with my own herbarium and botanical library. It is known here to those interested that I have offered to present them to our University whenever our Corporation will build a fire-proof building for their reception and make a moderate endowment for their preservation, care, and increase. Of late there are some intimations that a wealthy gentleman may build the requisite building, which will relieve a great part of my constant anxiety.

Believe me to remain, my dear Sir, with most respectful regards to your Mother and to the other members of your family known to me by correspondence

Faithfully yours

Asa Gray

P. S. In the future peaceful times for which we hope and pray, I trust my wife and I may be spared, and may be able, to visit the Western States, where we have many friends, among which those at Hayfield,* whom we have never yet seen, shall not be forgotten.

A. G.

* Name of Dr. Short's home place, now in the city of Louisville.

[*Elias Durand to William Short*]

Philadelphia, Febr. 24th, [18]64.

Wm. Short, Esqre.
Louisville.
Dear Sir,

Your revered father's herbarium has arrived safely, and has been received by our Members with enthusiastic demonstrations of admiration for its magnificence, and of gratitude towards your family for the generous gift. It is indeed the most splendid herbarium to be seen any where, for the good preservation and beauty of its specimens and for the admirable neatness and elegance of its arrangements.

I am now taking an inventory of the contents of each volume, to enable me to make up an index or key to the orders and genera contained in them *ad usum studentium.* The loose packages, some of which had not as yet been opened by your dear father, and contain undoubtedly many new species, will be gradually incorporated with the main herbarium which will have, in our botanical room, the place of honor which it so well deserves.

I can assure you, my dear Sir, with our friend Prof. Gray, that the Phil. Academy of Natural Sciences is the right place for depositing this treasure which has cost so much labor and given so many causes of enjoyment to your dear father; It will be appreciated and carefully preserved.

The package addressed to Mr. Bebb* of Washington has been sent to him. That to Mr. Eaton will be sent to him when I know his direction. As to Dr. Boott's, I am going to write to Dr. Gray to know what I shall do with it. Dr. Boott died in London about two months ago and has, I believe, a brother in Boston.

Believe me, my Dear Sir,
Very respectfully yours
E. Durand

*Michael S. Bebb (1833–1895), born in Ohio. During the Civil War he had a position in the Pension Bureau in Washington. Later he moved to northern Illinois and resumed his botanical work, especially on willows, on which he was an authority. He wrote the section on willows in the sixth edition of Gray's *Manual*. *Salix Bebbiana* was named for him by Sargent.

[*Asa Gray to a daughter of C. W. Short*]

Herbarium of Harvard University,
Botanic Garden, Cambridge, Mass.
August 5, 1879.

Hon. & Dear Madam

I respond at once to your letter of Aug. 1, and send you the announcement in Silliman's Journal, on which (& on a later) notice, the article in the Garden must have been founded.

Year after year have I hunted for that plant! and I grew sorrowful at having named after Dr. Short a plant that nobody could find.

So conspicuous for its absence had this rarity become, that friends of ours, botanizing in the mountains two years ago, were accosted with the question—"Found Shortia yet?" from people who had seen our anxious search for it. After all, the rediscovery was accidental, and by one not a botanist. Few botanical events have excited more interest at home and abroad; and your honored father is commemorated by perhaps the most interesting flower in N. America, with a counter-part in Japan.

Well, my wife and I, with three other botanists, passed the month of

June, 1, in a visit to the discovered locality—a small patch, at the foot of the mountains, and in a diligent search for more—as it no doubt belongs higher up in the mountains.* We *did not find more of it.* But I am not yet 69 years old, and I hope to try once more, having now narrowed the region in which the search should be made with some confidence.

But we had a delightful journey.

When your memorial is printed, please let me have a copy of it. Consider that I have an interest in the subject of it, next to his own descendants.

Excuse hurried line from a very busy man, & poor writer, and believe me to be always Yours very sincerely

Asa Gray

I have had more or less to do with the naming (beside the genus) of several species for Dr. Short.

Among them

Carex Shortii

Vesicaria Shortii [now *Lesquerella globosa* in Gray, 7th ed.]

Aster Shortii

Solidago Shortii.

A. G.

The flowering specimens are left in the hands of Mr. Hyams who is a plant dealer—Statesville, N. Car. They have been gathered scantily, not to endanger the stock. Next year you shall have a dried specimen, or better, a plant, to flower for yourself. A pretty, but modest thing.

A. G.

University of North Carolina,
Chapel Hill, N. C.

* Gray was wrong in this: He was misled by Michaux's label in the Paris Museum which said "hautes montagnes." All other stations since discovered are at lower altitudes.

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PROCEEDINGS OF THE FORTIETH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

UNIVERSITY OF NORTH CAROLINA, CHAPEL HILL

The fortieth annual meeting of the North Carolina Academy of Science was held at the University of North Carolina, April 25 and 26, 1941.

The first general session was called to order by President J. L. Stuckey at 10:00 A. M. The presentation of papers began at once and continued until 12:30. A section for the biochemists and physiologists met at the same time. The reading of papers before the general session was resumed at 2:00 and continued until 4:30, when, after a short recess, the Academy assembled for its annual business meeting.

The business meeting was called to order by President Stuckey. The minutes of the 1939 meeting were approved as published. After correction of an error in the officers of the Mathematics Section the minutes of the 1940 meeting were approved as published.

President Stuckey then called for reports from the various committees of the Academy. The reports of most of the committees had been mimeographed and circulated at the morning session.

REPORT OF THE EXECUTIVE COMMITTEE

The following business was transacted by correspondence.

The Executive Committee set the date for the annual meeting as April 25 and 26. It also set April 19 for its meeting to consider the affairs of the Academy.

The Executive Committee considered the question of recommending

Miss Lena Barber for life membership in the Academy. A recommendation is offered at the proper place.

The Executive Committee approved the assignment of the A. A. A. S. grant for research as soon after January 1 as feasible.

The Committee met in regular session on April 19, and transacted the following business. After a preliminary report on finances, the committee authorized the following expenditures:—(1) the cost of mimeographing the complete roll of membership, a copy of which is to be sent to each departmental head in the state; (2) the cost of a complete set of membership cards to be brought up to date; (3) employment of an assistant to take care of collection of dues during the meeting. As a matter of economy the committee decided to discontinue issuing membership cards.

The Committee received and accepted an invitation to hold the next annual meeting at the Woman's College of the University of North Carolina at Greensboro.

The President announced the appointment of the following committee on Resolutions:—E. L. Cocke, Chairman, D. B. Anderson and H. L. Blomquist.

The Committee after some discussion expressed its opinion that the Presidential Address should be printed along with the Proceedings. This custom, established long ago, has on occasion been unobserved.

The Committee added additional late papers to the program, and authorizied a Mathematics Section.

The Committee considered the relations of the Academy with the Elisha Mitchell Journal. Due to a lack of information and the desire of the Committee to coöperate with the Journal, the Committee wishes to express its willingness to coöperate in any way possible with the Journal.

The Committee reports that it has elected 82 members since the last meeting of the Academy. The list follows.

Andrews, James C., Dept. of Biological Chemistry, University of North Carolina.
Artom, Camillo, Dept. of Biochemistry, Wake Forest College.
Bagby, English, University of North Carolina.
Barkley, Key L., Dept. of Psychology, Woman's College of U. N. C.
Bayroff, A. G., Department of Psychology, University of North Carolina.
Beasley, William Lee, Jr., Field Secretary of North Carolina Forestry Association.
Bloomer, Robert Oliver, University of North Carolina.
Botany Club, Woman's College of U. N. C.

Boyer, Charles C., Dept. of Zoology, Duke University
Burkhart, Leland, Dept. of Agronomy, State College
Burgess, B. C., Vice-President, United Feldspar and Minerals Corp.
Busteed, Robert C., Dept. of Biology, A. S. T. C.
Butler, Howard N., Southern Pines, North Carolina.
Carpenter, J. Richard, Dept. of Biology, Black Mountain College.
Clarkson, Mrs. Edwin O., Charlotte, North Carolina.
Constable, E. W., State Department of Agriculture.
Cooper, Gerald Rice, Dept. of Biochemistry, Duke Medical School.
Darkis, Frederick R., Dept. of Chemistry, Duke University.
DeLoach, Will Scott, East Carolina Teacher's College.
Dosier, J. P., 15 Mildred Avenue, Asheville, N. C.
Dosier, Mrs. John P., 15 Mildred Avenue, Asheville, N. C.
Experimenters Club, Millbrook High School, Rt. 1, Raleigh, N. C.
Ferrill, H. Ward, Dept. of Physiology, University of North Carolina.
Fisher, Doris B., Concord Public Schools.
Flowers, R. L., President, Duke University.
French, John R. P., Jr., Dept. of Psychology, Black Mountain College.
Garner, Lofton Leroy, University of North Carolina.
Gill, Ruth Ellen, Kittrell, North Carolina.
Gordon, Seth, Jr., State Department of Conservation and Development.
Gray, Cora E., Dept. of Home Economics, Catawba College.
Hafer, Claud, Southern Pines, North Carolina.
Hardcastle, A. B., Dept. of Zoology, Duke University.
Hendricks, Caroline, Botany Dept., University of North Carolina.
Holt, Lawrence B., Wake Forest College.
Hood, Frazer, Dept. of Psychology, Davidson College.
Hoyle, Vinton A., University of North Carolina.
Humm, Harold J., Dept. of Botany, Duke University.
Jeter, Douglas D., Davidson College.
Johnson, John, Dept. of Biology, Mars Hill College.
Kemp, E. H., Dept. of Psychology, Duke University.
Kilgore, B. W., State College.
LeClair, F. J., United States Soil Conservation Service, University of North Carolina.
Livingston, Robert B., Dept. of Botany, Duke University.
Lyddane, R. B. H., Dept. of Physics, University of North Carolina.
MacPhee, Halsey M., Dept. of Psychology, University of North Carolina.
Marble, Guita, Dept. of Chemistry, Woman's College of U. N. C.
Markham, Edwin Carlyle, University of North Carolina.
Martin, Romeo J., University of North Carolina.
Mecklenburg Audubon Club, Charlotte, North Carolina.
Miller, Augustus T., Jr., Dept. of Physiology, Wake Forest College.
Miller, J. Isabel, Dorland Bell School, Hot Springs, N. C.
Murdock, T. G., State Dept. of Conservation and Development.
Nature Study Club, Durham High School.
Neuman, Robert B., University of North Carolina.

Odum, Howard W., Institute for Research in Social Science, University of North Carolina.
Perry, William D., University of North Carolina.
Phy-Chem Club, Durham High School.
Pratt, Joseph H., Dept. of Chemical Mineralogy, University of North Carolina.
Radford, Albert E., Botany Dept., University of North Carolina.
Raynal, Charles E., Statesville, North Carolina.
Rethlingshafer, Dorothy, Dept. of Psychology, University of North Carolina.
Rosen, Nathan, Physics Dept., Black Mountain College.
Russell, Phillips, Journalism Dept., University of North Carolina
Schoof, Herbert F., Dept. of Zoology, State College.
Smith, Clyde R., Dept. of Entomology, State College.
Sprunt, Douglas H., Medical School, Duke University.
Stainback, Raymond F., University of North Carolina.
Stanland, Marion, Woman's College of U. N. C.
Straus, Erwin W., Dept. of Psychiatry, Black Mountain College.
Straus, Fritz L., Chemist, Ecusta Paper Corporation.
Swett, Francis H., Dept. of Anatomy, Duke University.
Talton, I. B., Concord, North Carolina.
Tilley, Edward B., Pinehurst Public School.
Wells, Herbert S., Dept. of Physiology and Pharmacology, Bowman Gray School of Medicine.
West, J. Frank, Dept. of Geological Engineering, State College.
White, Raymond Cyrus, Dept. of Chemistry, State College.
White, W. Tom, Jr., 1324 Eye Street, Washington, D. C.
Williams, Louis G., New Hanover High School.
Wilson, Charles C., Dept. of Botany, Duke University.
Wilson, Dorothy E., Durham High School.
Wilson, John W., Dept. of Zoology, Duke University.
Wyatt, Walter J., Wake Forest College.
Zoology Field Club, Woman's College of U. N. C.

The Committee submits the following recommendations:

That Miss Lena Barber be elected to Life Membership in the Academy. Passed.

That the High School Committee be authorized to continue its activities as set up at present and that the project award of $20 in cash be presented during the dinner Friday evening. Passed.

That the payment of all bills submitted by the Treasurer for the current year shall, upon the approval of the President, be authorized. Passed.

That the Treasurer's report, when verified by the Auditing Committee, shall be authorized for publication. Passed.

That, in view of the fact that the next annual meeting will complete

forty years of activity, a special committee be set up to consider plans for an anniversary meeting. Passed.

J. L. STUCKEY, *President*,
O. J. THIES,
O. C. BRADBURY,
E. H. HALL,
A. S. PEARSE,
BERT CUNNINGHAM, *Secretary*.

The report of the Executive Committee was adopted as a whole.

A preliminary report was submitted by the Treasurer. It was voted that a final report, based upon the Bank Statement of June 1, be submitted to the Auditing Committee and upon its approval, said report should be published and become a part of the Proceedings of this meeting The report has been submitted and the following statement received from the Auditing Committee:

REPORT OF THE AUDITING COMMITTEE

On this twelfth day of August, 1941, this account was examined and found correct. R. W. Bost, E. T. Browne, H. R. Totten (Chairman).

The detailed Treasurer's Report as submitted and approved has been condensed and is published here in the condensed form. Any one wishing a detailed copy may secure the same upon request.

Treasurer's Report

Receipts	
A A A S Grant 1940	$75 00
Dues 1940	24 00
Chemistry program 1940	7 50
A A A S Grant 1941	75 00
American Institute Grant	163 15
Mrs E Barnhill Clarkson Grant	50 00
Dues 1941	684 00
Chemistry program 1941	5 00
N. C. Forestry Award	20.00
Rubber Check replacement	2 00
Dues 1942	4 00
Total Receipts	1,109 65
Expenditures:	
1940 A. A. A. S. Grant	$75.00
Printing	80.59

Postage	50.00	
Stenographic Aid	148.00	
1941 A. A. A. S. Grant	75.00	
Forestry Essay prize	20.00	
Academy prize	20.00	
Mitchell Journal	300.00	
American Institute Account	113.15	
Audubon Society (Lantern slides)	50.00	
Secretary's Commission	81.00	
Miscellaneous	50.18	
Total Expenditures	1,062.92	
Operating Balance 1940–41	46.73	
	1,109.65	
Summary of Accounts:		
Balance, Checking Account, 6/1/40	208.04	
Total Receipts	1,109.65	
	1,317.69	
Total Expenditures		1,062.92
Bank Balance 6/1/41		254.77
		1,317.69
Savings Account Balance, 6/1/40	408.61	
Interest	8.20	
Savings Account Balance, 6/1/41	416.81	

REPORT OF THE APPRAISAL COMMITTEE

This committee has received no requests for appraisal and so has no appraisals to report.

P. M. GINNINGS, *Chairman.*

Report was adopted and the committee discharged.

REPORT OF THE RESEARCH GRANT COMMITTEE

Applications for only two projects were received:

A canvass of the Committee resulted in a majority voting for the fund to be given to Charles H. Lindsley and Nathan Rosen, Black Mountain College, for their work on *An analysis of the Zeeman patterns in the spectrum of palladium obtained in a strong magnetic field.*

B. W. WELLS, *Chairman.*

Report adopted.

REPORT OF THE REPRESENTATIVE TO THE COUNCIL OF THE A. A. A. S.

Your representative attended all of the Council Meetings. Since reports of these have already been printed, no further report is needed here.

BERT CUNNINGHAM, *Representative.*

Report adopted.

REPORT OF THE HIGH SCHOOL SCIENCE COMMITTEE

The Committee has continued to work on the projects which were undertaken last year.

The Committee was represented at each of the District Meetings where attention was called to the various methods by which the Academy could and would coöperate with High School teachers. As a result of these meetings we distributed about 75 pamphlets (provided by the American Institute) on "How to Organize a Science Club." From these meetings we have also had a large number of requests for the use of lantern slides.

Proportionately, our lantern slide loans have not reached as many people as last year. We now have two hand-colored sets of Wild Flower Slides, one on the endocrine system, and one hand-colored set on the birds of North Carolina. We have promised to us, and we understand nearing completion, a set of slides on the forests of North Carolina. It would be desirable to have a set on the reptiles and another set on entomology. The bird slides were donated by Mrs. E. O. Clarkson of Charlotte, and the forestry slides are being provided by the North Carolina Forestry Association.

We have been able to help organize four science fairs—one at Buies Creek, another at Greensboro, a third at Greenville, and the fourth at Cullowhee. The chairman of the committee attended three of these. The fairs have proved to be very stimulating for the region in which they are held, not only to the high school students, but also to the institutions in which they are held. It is highly desirable that more fairs be organized. It should be recalled that the winners of the projects at the individual fairs are entitled to present their projects at the time of the Academy and that one of the exhibits will be selected to receive the $20 Academy award. The winner is selected by a ballot of the membership of the Academy.

The meeting last year for high school teachers met with considerable

success and we have arranged another meeting for this year. The program is printed with the Academy program.

In response to a considerable number of requests, we have organized a meeting and program for the sponsors of high school science clubs. The program is printed with the Academy program.

The Committee has been able to secure $100 from the American Institute to further the work with the high school clubs, in addition to a sufficient number of pamphlets on "How to Organize a Science Club."

The Committee has also received a grant of $20 from the North Carolina Forestry Association to be awarded for a worthy essay in the field of forestry written by a high school student. The date for the essays was set before we knew the Academy would meet a week earlier, but it is to be hoped that we shall be able to announce the winner at this meeting.

The Committee also considered the nominations of the High School Science Clubs for Junior Membership in the American Association for Advancement of Science. Mr. Buster Brown of Buies Creek High School was nominated for the "boy" membership and Miss Martha Ballard of Kipling for the "girl" membership. They were properly elected by the A. A. A. S.

The Committee recommends: first, that the Projects Award be continued; second, that the Academy express its appreciation for the help given by the American Institute in the high school program, and to Mrs. E. O. Clarkson for her gift of Bird Slides; third, that the program for high school teachers be continued and if the sponsors' meeting proves worth while that it be continued.

Respectfully submitted,

C. F. DODSON,
J. H. HIGHSMITH,
R. J. SLAY,
J. W. WOOD,
M. L. BRAUN,
B. CUNNINGHAM, *Chairman.*

Report was adopted.

REPORT OF THE REPRESENTATIVE TO THE ACADEMY CONFERENCE

(A more detailed report was submitted in mimeographed form to members present at the morning meeting. A few more copies are available for any desiring one.)

Twenty-eight representatives of nineteen Academies of Science met at the fourteenth annual conference which was held at Philadelphia under the chairmanship of Dr. J. C. Gilman of the Iowa Academy. The opening talk on "Methods of Bringing the Academy in Closer Relations with other Organizations" by Dr. P. D. Strausburg of West Virginia Academy pointed out that no societies will submerge themselves to join a group. They always insist that their freedom be maintained.

Dr. W. F. Rudd of Virginia spoke of "Long Time Planning for Academies of Science." Virginia has a committee of 19 to outline the ideal objectives and contributions of their state Academy for the next five years. They are proceeding by questioning the membership which consists of between 800–1000 and studying the replies.

The need for an organization intermediate between the Junior and the Senior Academies has been recognized. There are approximately 150 College Clubs which may be approached to form the same type of associations as the Junior Academies of Science in relation to the Senior Academies. Texas has such an organization.

The committee on the Junior Academy gave no report but was continued.

It is urged that each Academy give consideration to the recommendations contained in these minutes at its next regular meeting and inform the undersigned of any action taken, or of its attitude relative to the recommendations.

Dr. S. W. Bilsing of Texas after serving eight years as Secretary of the Conference was made President for next year and Dr. Earl Light, Secretary of the Pennsylvania Academy, was made Secretary of the Conference.

At the Academy dinner, those present introduced themselves and remarks were made relative to the history of the Academy Conference and the relations of the A. A. A. S. and the Academies.

The committee on the Junior Academy referred to above met on December 28 and the following is the report of its action:

Members present: Dr. E. C. L. Miller (Virginia Academy), Dr. Bert Cunningham (North Carolina Academy), Dr. J. C. Gilman (Iowa Academy), Dr. Lyell J. Thomas (Illinois Academy), Dr. H. H. Sheldon (Amer. Inst. of N. Y. City), and Dr. Howard E. Enders (Indiana Academy). Dr. S. W. Bilsing (Texas Academy), Secretary of the Academy Conference, attended *ex officio*.

The affiliated Academies of Science have encouraged the development

of Junior Academies of Science in the high schools of twelve or thirteen states.

The question of the possible affiliation of collegiate groups in a similar relationship with the state academies was discussed. The Texas Academy of Science has a successful set-up for collegiate groups. It has a separate state sponsor and separate state program for collegiate groups. On the occasion of its state meeting a committee appraises the merits of the several papers and awards first, second, and third prizes of $25, $15, and $10 for the papers presented.

This committee is laying plans for the collections of data to determine which of the state academies now accept persons from the undergraduate student body in colleges into membership in the state academy. A report is to be made at the Dallas meeting. It also proposes to determine the distribution of college science clubs within the various provinces of the affiliated academies. Dr. H. H. Sheldon was selected to undertake these tasks in as much as it will be feasible to operate through his extensive staff.

On motion of H. H. Sheldon and duly passed: The Secretary of this committee is requested to write to the Secretary of the Academy Conference suggesting that Dr. C. B. Godbey, Professor of Chemistry, Southwestern University, Georgetown, Texas, be invited to present a paper at the Dallas meeting of the Academy Conference on the practice of the Texas Academy with respect to collegiate members.

Dr. H. H. Sheldon was requested to take over the project of soliciting circulating and exhibit materials (known as "traveling kits") from manufacturers, or industries, to serve as program material for the clubs of the several state academies which have an affiliated Junior Academy or affiliated clubs.

The secretary of the A. A. A. S. was requested to formulate a procedure of nomination of the "Best Boy" and "Best Girl" as Honorary Members of the A. A. A. S., which may be sent to the several affiliated state academies of science: also that the A. A. A. S. formulate some procedure that will recognize the Junior Honorary Members each year at its annual meeting.

BERT CUNNINGHAM, *Representative.*

The report was adopted.

REPORT OF THE COMMITTEE ON CONSERVATION

Your Committee on Conservation has had no new problem presented to it for consideration during the past year and no matter demanding

action by the Academy has been brought to our attention by any of its members. There are, however, two unfinished projects which, to be accomplished, must be kept stirred up, for in the effort to procure public benefits eternal effort is the price of success. I refer to the expressed interest of the Academy in the acquisition by the Government for the permanent benefit of our people of the Dismal Swamp in North Carolina and Virginia, and the so-called "Primeval Forest" in the western part of this State. Both of these were mentioned in last year's report of this Committee. This, therefore, is only a progress report, or, lacking progress, simply an action report.

Dismal Swamp. Following last year's meeting of the Academy, I learned of the passage of a resolution by the 18th annual meeting of the Isaak Walton League of America at Chicago which reads as follows:

"Be it resolved that the Isaak Walton League of America, in convention assembled March 30, 1940, expresses its desire to have the 82,000 and more acres in the Dismal Swamp and Lake Drummond area incorporated into the National Forests and Game preserves of the United States of America, and requests acquisition of the area as being of national importance and comparable in importance to many areas acquired by the federal government for forest and game preserve areas.

Be it further resolved—That the matter be laid before the proper governmental agency and that the delegates from Norfolk chapter and Virginia and from the adjoining states be requested to coöperate in the objective herein embraced."

The president of the Association of Isaak Walton League Chapters in Virginia, referring to this resolution, wrote: There is much interest in Southeastern Virginia in the incorporation of the Dismal Swamp area, which lies in Southeastern Virginia and Eastern North Carolina in the National Forest Projects of the Federal Government . . . on behalf of the Association of Isaak Walton League Chapters in Virginia, I will be pleased to aid in the attainment of the objective."

Last September I represented this Academy at a meeting of the Isaak Walton League of Virginia Chapters in Richmond, where I advocated federal acquisition and the multiple use policy of the United States Forest Service. A special committee was appointed to consider and coördinate the several objectives which should be presented to the Federal Government as reasons for acquiring this area of more than 200,000 acres, half of which lies in five North Carolina counties. Following this meeting a program of management was outlined by letter to the Virginia Academy of Science as follows:

1. Protection from fire which involves fire breaks and truck trails.

2. Utilization of the timber crops on certain areas in the interest of local industries and residents.

3. The establishment of one or more natural areas allowing the different types to reëstablish themselves.

4. Management of the whole area as a wildlife forest, a portion being set aside as sanctuary for native big game, while on the remaining part regulated hunting of big game be allowed.

5. Recreation to be encouraged, stressing the interest in the area of scientists, naturalists, sportsmen, etc.

6. Historic and scenic values to be preserved. The early association of George Washington with the area is an interesting feature.

The above program of multiple use could best be effected through administration as a National Forest.

While the Government offers little encouragement for the early acquisition of this unique area, sustained interest and pressure will, I have no doubt, bring the desired result.

Primeval Forest. The conditions surrounding the proposed acquisition of the Ravenel Tract or "Primeval Forest" in Macon County have changed very materially with the death of Mr. C. P. Ravenel last year. His widow now is said to be anxious to realize on this property and, according to reports, has asked $100 per acre for the whole property. The United States Forest Service cannot justify purchase at anything like such a price even if they had money available, which they have not. An appeal was made to Congressman Weaver to use his influence to secure this tract by the Government. Mr. Weaver heard from the Washington office of the Forest Service to the effect that "There was considerable agreement as to the inspirational, esthetic and scientific values. That fact, plus the further fact of very limited funds available for forest-land purchases, led to the conclusion, at that time, that the use of the limited available funds to acquire the tract would be very difficult of justification. It is understood that the owner of the property demands a consideration of about $100 per acre, at least for that part of the holding still supporting commercial timber. Such examinations as have been made by the members of the Forest Service create serious doubt as to the existence of physical values which would justify more than a minor part of the $100 per acre asked for the property. The consideration acceptable to the owner therefore would have to be based largely upon rather intangible values, not only difficult of substantiation but also beyond the explicit or implicit purview of the Weeks Law."

Mr. Weaver also wrote to the Regional Forester in Atlanta who re-

plied that "the whole subject of the possible purchase of the Primeval Forest has been given a great deal of consideration both in the field, and in this office and our Washington office. I personally have visited the area on two occasions. It is very generally recognized by members of the Forest Service that the Primeval Forest has very high recreational, inspirational, and scientific values. However, the price at which it appears to be held definitely precludes its purchase under the provisions of the Weeks Act." I also talked to Mr. Kircher about the property with apparently the same result. However, a suggestion was made that if the property could be secured at a reasonable figure, the part remote from travel might be lumbered and the portion more valuable for scenic, scientific, and recreational use could be retained in its present condition. However, unless some money can be made available even that possibility is more or less remote. If the membership of the Academy could all show as keen an interest in saving this property for the public as two or three members of the faculty of the State University have shown, I believe some method could be worked out to save this marvelous tract of virgin timber.

C. F. KORSTIAN,
W. C. COKER,
J. P. GIVLER,
H. J. OOSTING,
J. S. HOLMES, *Chairman.*

The report was adopted.

At this point Dr. J. S. Holmes presented the following resolution bearing on part of the foregoing report.

RESOLUTION: SPECIAL COMMITTEE ON "THE PRIMEVAL FOREST." In view of the outstanding scientific and educational values of the "Primeval Forest" in Macon County, North Carolina, and the imminent danger of its destruction by falling into the possession of those who would be unwilling or unable to preserve it, the North Carolina Academy of Science in regular annual meeting herewith commends every effort being made to perpetuate it in its present original condition and herewith urges the appointment of a special committee composed of one representative from each of the higher educational institutions of the State, such committee to elect its own chairman, to devise ways and means of getting this property into public ownership and to assure its continuous use as a natural and recreational area.

The resolution was adopted and the incoming President instructed to name the committee.

The Nominating Committee presented the following slate:

President: R. E. Coker, University of North Carolina.

Vice-president: C. N. Warfield, Woman's College of U. N. C.

Member of Executive Committee (3 yrs.): D. B. Anderson, State College.

Members of the Research Grant Committee: C. F. Korstian, Duke University; and J. N. Couch, University of North Carolina.

The President called for nominations from the floor. There were none and the Secretary was instructed to cast an unanimous ballot for each nominee. This was properly done and the President declared each elected.

The following awards, made by the appropriate committees and judges, were announced:

A. A. A. S. Grant for research ($75) to C. H. Lindsley and N. Rosen of Black Mountain College.

Poteat Award ($50) to Miss Alma Whiffen of the University of North Carolina.

Forestry Essay ($20) divided between Omega Rice of the Dorland Bell School at Hot Springs and William Anderson of the Hayesville High School.

Academy High School Award ($20) to John M. Stewart of Alamance High School.

The following resolution was presented and adopted by a rising vote.

REPORT OF A SPECIAL RESOLUTION COMMITTEE. The death of Harvey Park Barret on July 30, 1940, deprives us of one of our highly valued members. He was a worthy representative of families that played active and important parts in the establishment and development of these United States. Among his forbears are such names as William Christian, Benjamin Logan, and William Short. Born on May 18, 1885, in Louisville, Ky., he received his early education in that city. In 1904 he obtained the B. A. degree from Centre College (Danville, Ky.), and in 1908 graduated in Medicine at the University of Louisville.

From the beginning of his career Barret was interested in laboratory work and in research. He engaged in advanced studies at the University of Michigan, was for several years an associate professor of Pathology and Bacteriology at the University of Louisville, and served as bacteriologist for the Louisville health department. In 1917 he came to North Carolina as pathologist for the Charlotte Sanatorium. He also established in Charlotte a private laboratory for Clinical Pathology,

serving other hospitals and practicing physicians in that community. He was the pioneer in this special field in this state and his laboratory played an important part in the development of scientific medicine here during the past two decades.

He was a master technician, unusually skilled in laboratory procedures, a diligent student, widely read in general medicine as well as in pathology, and above all a man of sound judgment and sterling integrity who commanded the confidence and affection of all his associates. He was deeply imbued with the spirit of research. In spite of the burdens of a busy practice, he constantly carried on scientific investigation. When broken health required retirement from active practice, he erected a small laboratory at his home and continued his studies there.

Even virtues may be too extreme. He was modest and shy to a fault. It was painful and almost impossible for him to read a paper or engage in discussions on the floor at society meetings. This prevented his being as widely known as his abilities and achievements deserved, and it deprived his colleagues of the benefit of much of his knowledge and sound judgment. His abhorrence of publishing anything but complete and well proven results prevented him from being a prolific writer, but his articles, brief and to the point, appeared in the Journal of the American Medical Association, the Journal of Laboratory and Clinical Medicine, the Archives of Pediatrics, the American Journal of Tropical Medicine, the American Journal of Hygiene, the Journal of Parasitology, the Annals of Tropical Medicine and Parasitology. Perhaps his most significant contributions were on the intestinal fauna and flora, especially the cultivation of parasitic protozoa. One of those organisms, discovered by him in the turtle intestine, was named for him by Taliaferro and Holmes (*Endamoeba Barreti*).

His activities were not limited to medicine. He became interested in minerals and developed a fine collection of those found in this state. During his college days he had been an athlete and for many years he helped in coaching and did much to promote athletics in the Charlotte Schools. He was generous with his money as well as his time. It was through his aid that many a high school student was able to attend college. No one knows how many others received his assistance in their financial difficulties.

We have lost an able scientist, a fine citizen and a true friend. We wish to express to his family our sense of great loss and to extend to them our deep sympathy.

J. B. BULLITT, *Chairman.*

REPORT OF THE COMMITTEE ON RESOLUTIONS

Whereas the accomodations provided for the annual meeting of the North Carolina Academy of Science have been most adequate, the arrangement most efficient, and the entertainment outstanding, and

Whereas many exceptional favors and gracious courtesies have been extended to the members and to the attendants upon the meetings, therefore, be it

RESOLVED: That the North Carolina Academy of Science record its sincere appreciation to President Frank P. Graham, the local committees, the faculty and students of the University of North Carolina, to the Elisha Mitchell Scientific Society, and to all who have had a part in making this meeting both pleasant and profitable.

DONALD B. ANDERSON,
H. L. BLOMQUIST,
ELTON C. COCKE

Report adopted.

The personnel of the standing committees follows:

Executive: R. E. Coker, C. N. Warfield, B. Cunningham, E. H. Hall, A. S. Pearse, D. B. Anderson.

Research Grants Committee: B. W. Wells (1942) Chairman, O. C. Bradbury (1943), H. D. Crockford (1943), C. F. Korstian (1944), J. N. Couch (1944).

The following sectional officers were elected by the respective groups:

Botany: Chairman, P. J. Kramer; Secretary, E. H. Hall (1943). Attendance estimated 40–50.

Biochemistry and Physiology: Chairman, J. C. Andrews; Secretary, G. H. Satterfield (1943). Attendance more than 40.

Geology: Chairman, J. L. Stuckey; Secretary, Willard Berry (1942). Attendance more than 50.

Mathematics: Chairman, J. M. Clarkson; Secretary, J. W. Lasley, Jr. (1943). Attendance 15.

Physics: Section had no meeting. Secretary, F. W. Lancaster (1942).

Psychology: Chairman, Frazer Hood; Secretary, J. F. Dashiell (1942). Attendance estimated 35.

Zoology: Chairman, F. H. McCutcheon; Secretary, Z. P. Metcalf (1942). Attendance estimated 35.

High School Science Teachers: Chairman, Dorothy Aycock; Secretary, J. W. Wood (1942). Attendance estimated 20.

President R. E. Coker announces the following committees to serve during 1941–42:

Auditing Committee:

Anderson, D. B., *Chairman*, State College, Raleigh, N. C.
Boomhour, J. G., Meredith College, Raleigh, N. C.
Derieux, J. B., State College, Raleigh, N. C.

Conservation Committee:

Holmes, J. S., *Chairman*, State Forester, 302 Forest Rd., Raleigh, N. C.
Givler, J. P., W. C. U. N. C., Greensboro, N. C.
Korstian, C. F., Forestry Duke University, Durham, N. C.
Coker, W. C., University of North Carolina, Chapel Hill, N. C.
Oosting, H. J., Duke University, Durham, N. C.

High School Science Committee:

Cunningham, Bert, *Chairman*, Duke University, Durham, N. C.
Braun, M. L., Catawba College, Salisbury, N. C.
Dodson, C. F., Western Carolina Teachers College, Cullowhee, N. C.
Highsmith, J. H., Department of Education, Raleigh, N. C.
Slay, R. J., East Carolina Teachers College, Greenville, N. C.
Wood, J. W., Durham High School, Durham, N. C.

Legislative Committee:

Berry, Willard, *Chairman*, Duke University, Durham, N. C.
Bost, R. W., University of North Carolina, Chapel Hill, N. C.
Prytherch, H. F., U. S. Bureau of Fisheries, Beaufort, N. C.
Wells, B. W., State College, Raleigh, N. C.

Necrology Committee:

Emory, S. T., University of North Carolina, Chapel Hill, N. C.
Finster, Miss Ethel B., A. N. and T. C., Asheville, N. C.
Fulton, B. B., State College, Raleigh, N. C.
Isbell, Nevill, Wake Forest College, Wake Forest, N. C.
Jeffers, Katharine R., Duke University, Durham, N. C.
Lyon, S. C., Davidson College, Davidson, N. C.
DeLoach, W. S., East Carolina Teachers College, Greenville, N. C.
Morgan, Karl Z., Lenoir Rhyne College, Hickory, N. C.
Ramsey, G. G., Catawba College, Salisbury, N. C.
Ritchie, Lawrence S., W. C. U. N. C., Greensboro, N. C.

Nominating Committee:

Holmes, J. S., *Chairman*, Raleigh, N. C.
Bullitt, J. B., University of North Carolina, Chapel Hill, N. C.
Ginnings, P. M., Greensboro College, Greensboro, N. C.

Poteat Award Committee:

Porter, W. L., *Chairman*, Davidson College, Davidson, N. C.
Adams, D. K., Duke University, Durham, N. C.
Berry, Willard, Duke University, Durham, N. C.
Braun, M. L., Catawba College, Salisbury, N. C.
Hall, E. W., Woman's College of University of North Carolina, Greensboro, N. C.
Mackie, E. L., University of North Carolina, Chapel Hill, N. C.
Satterfield, G. H., State College, Raleigh, N. C.

Committee on Resolutions:

Campbell, E. G., *Chairman*, Guilford College, N. C.
George, W. C., University of North Carolina, Chapel Hill, N. C.
Higgins, C. H., Salem College, Winston-Salem, N. C.

Special Committee

Committee on Primeval Forest:

Dr. J. S. Holmes, *Chairman*, 302 Forest Rd., Raleigh, N. C.
Wells, B. W., State College, Raleigh, N. C.
Bradbury, O. C., Wake Forest College, Wake Forest, N. C.
Oosting, H. J., Duke University, Durham, N. C.
Thiel, A. F., W. C. U. N. C., Greensboro, N. C.
Weil, Lionel, 611 Park Avenue, Goldsboro, N. C.
Cunningham, Bert, Ex-Officio Member, Duke University, Durham, N. C.

The University gave the membership a complimentary dinner at which Mr. Stewart was introduced and was given the Academy High School Award. This was a most delightful occasion.

At 8:00 P. M. the Academy assembled to hear the Presidential Address. Vice-president Thies presided and introduced Dean Hobbs of the University of North Carolina who welcomed the Academy to Chapel Hill and the University. The Presidential Address, "Man and Minerals," was delivered by President J. L. Stuckey.

After the meeting the Academy enjoyed several hours of good fellowship at a smoker tendered by the Elisha Mitchell Scientific Society.

Saturday morning was devoted to sectional meetings, all well attended, and all provided with excellent papers. These sectional groups are growing rapidly both in size and interest.

The following papers were presented. Those marked with an "x" are abstracted in the Proceedings. Those marked with an "*" are published in full.

GENERAL SESSION

Farming by theory. L. G. WILLIS, State College.

The oxidation of trivalent chromium by 30% hydrogen peroxide in alkaline solution, and the effect of zinc and magnesium on this reaction. O. J. THIES, JR., AND J. W. KERR, Davidson.

x*Relation of chemical industries of North Carolina and adjoining states to national defense.* E. E. RANDOLPH, State College.

x*Experimental study of group panic.* J. R. P. FRENCH, JR., Black Mountain College.

The effect of temperature on the growth and development of three human pathogenic fungi. N. F. CONANT, Duke.

Drifting seaweeds at Beaufort, N. C. H. L. BLOMQUIST, Duke.

x*Psychology of phobias.* E. W. STRAUS, Black Mountain College.

Turgor and cell enlargement in cotton. D. B. ANDERSON, State College.

Catalysis of alcohols over certain North Carolina minerals. NEVILL ISBELL, Wake Forest College.

x*Some early human embryos with particular reference to the prochordal plate.* W. C. GEORGE, U. N. C.

Bacteria associated with the leaf nodules of Psychotria bacteriophila. H. J. HUMM, Duke.

x*Organic deposits of the lower Cape Fear peninsula.* B. W. WELLS AND I. V. SHUNK, State College.

Cut-throat competition in the sea. H. F. PRYTHERCH, U. S. Fisheries, Beaufort, N. C.

Experimental evidence from the malleus-incus asymmetrical articulation as the cause of aural harmonies. OTTO STUHLMAN, JR., U. N. C.

The distribution of dune vegetation and the effect of salt spray. H. J OOSTING AND W. D. BILLINGS, Duke.

x*The volcanic eruption in North Carolina in 1811.* A. H. GODBEY.

Zeeman effect in Palladium spectrum. C. H. LINDSLEY AND N. ROSEN, Black Mountain College.

A student polarimeter using polaroid. O. K. RICE, U. N. C.

Nutrient deficiency symptoms in peanut plant (by title). L. BURKHART, State.

Failure of the Tacoma Narrows Bridge. T. E. HICKERSON, U. N. C.

Mineral deficient strawberry plants (by title). R. A. LINEBERRY AND L. F. BURKHART, Raleigh.

BIOCHEMISTRY AND PHYSIOLOGY SECTION

x*Human plasma lipids and proteins in filtration through membranes of graded permeabilities.* C. ARTOM AND J. A. FREEMAN, Wake Forest.

x*The ascorbic acid content of turnips.* W. T. BURNETT AND G. H. SATTERFIELD, State College.

The intermediary metabolism of nicotinic acid. W. J. DANN AND P. HANDLER, Duke.

The effect of daily administration of insulin on the growth of the white rat. H. W. FERRILL, U. N. C.

x*Some observations on dark adaptation and vitamin A metabolism.* W. J. DANN AND M. YARBOROUGH, Duke.

x*Some nutritionally important minerals in the scuppernong grape.* MARGARET KRAMER AND G. H. SATTERFIELD, Meredith and State College.

Some properties of the fig enzyme. J. C. ANDREWS AND W. E. CORNATZER, U. N. C.

The isolated intestinal loop in the dog as a technique for studying the rates of absorption of quinine salts. C. E. ANDERSON AND J. C. ANDREWS, U. N. C.

BOTANY SECTION

x*Cytological studies in the Oryzeae and Zizaneae.* W. V. BROWN, Duke.

Systematic anatomy of Ericaceae. J. E. ADAMS AND H. T. COX, U. N. C.

x*A bog community in southeastern North Carolina.* M. F. BUELL AND R. L. CAIN, State College.

Relation between absorption and exudation in tomato. C. C. WILSON, Duke.

x*The role of chytrids in cellulose decomposition.* ALMA J. WHIFFEN, U. N. C.

Some notes on the Mucorales of the Southeastern States. G. A. CHRISTENBERRY, Meredith College.

Some aspects of fertilization in Lilium. L. ANDERSON, Duke.

The genus Codium at Beaufort, N. C. L. G. WILLIAMS, Wilmington.

x*Heterochromosome formation in Benzoin aestivale.* H. W. JENSEN, Asheville Farm School.

x*The cause of low water loss from cacti and other plant materials.* P. J. KRAMER, Duke.

x*New and rare North Carolina algae.* L. A. WHITFORD, State College.

x*Structure and action of cilia in aquatic fungi.* J. N. COUCH, U. N. C.

x*Starch storage in roots of a plant of Echinodorus radicans.* W. V. BROWN, Duke.

The effect of altitude on the composition of grasslands in central Colorado. R. B. LIVINGSTON, Duke.

GEOLOGY SECTION

Further studies of Carolina bays. W. F. PROUTY, U. N. C.

The origin of the Belton Fault complex, Cass County, Missouri. J. R. CLAIR, U. N. C.

x*Patination as a chronometer in archaeology.* A. H. GODBEY.

x*Manganese in North Carolina.* T. G. MURDOCK, Raleigh.

**History of geological investigation in North Carolina.* J. H. PRATT, Chapel Hill, N. C.

x*Mineral resources of the South.* G. W. CRICKMAY, University of Georgia.

x*Well No. 2, Camp Davis, North Carolina.* WILLARD BERRY, Duke.

x*Limonite pseudomorphs after pyrite in the Chapel Hill area.* ROBERT NEUMAN, U. N. C.

History of the North Carolina Geological Survey. R. J. MARTIN, U. N. C.

x*Effects of varying amounts of rainfall upon topography as illustrated by the trade-wind climate of the Hawaiian Islands.* G. R. MacCarthy, U. N. C.

x*Observations on the structure of the Blue Ridge in central Virginia.* R. O. BLOOMER, U. N. C.

x*Silurian of eastern Tennessee.* W. F. PROUTY, U. N. C.

MATHEMATICS SECTION

Completely convex functions. R. P. BOAS, JR., Duke.

x*Concerning I-normal and H-normal matrices.* E. T. BROWNE, U. N. C.

x*The significance of a critical ratio.* J. A. GREENWOOD, Duke.

x*A continuous one-parameter family of plane curves and some associated curves.* L. L. GARNER, U. N. C.

PSYCHOLOGY SECTION

x*Changes in students' attitudes during four years in college.* K. L. BARKLEY, W. C. U. N. C.

x*Change in personality trait ratings during attendance at college.* R. R. ULLMAN, Lenoir Rhyne.

x*Towards a definition of propaganda.* E. H. HENDERSON, Meredith College.

x*Inter-relational influences of three different adjunctive stimuli in punch-board maze performance.* H. M. MACPHEE, U. N. C.

Measurement of a motor set. DOROTHY RETHLINGSHAFER, U. N. C.

x*A preliminary study of imitational learning in white rats.* A. G. BAYROFF, U. N. C.

x*The localization of function in the cochlea as determined by the recording of electrical potentials.* E. H. KEMP, Duke.

x*After-imagery of some color-blind observers.* J. F. DASHIELL and C. C. TAYLOR, U. N. C.

x*Opportunities for psychologists in North Carolina.* WILLIAM MCGEHEE, State College.

ZOOLOGY SECTION

x*A sporozoan parasite in the testes of the menhaden.* A. B. HARDCASTLE, Duke.

Some observations on the mating of honeybees (Apis mellifera). F. B. MEACHAM, State College.

x*Anatomy of the gonads of an ascidian (Styela plicata* Lesueur). G. H. TUCKER, Duke.

x*Another predatory webspinning fly larva.* B. B. FULTON, State College.

Hemoglobin as an oxygen vehicle in Camallanus trispinosus. G. W. WHARTON, Duke.

The specific oxygen affinity of hemoglobin in splenectomized animals. F. H. MCCUTCHEON, State College.

Cell types and clotting reactions in the sand-dollar, Mellitia. C. G. BOOKHOUT AND NELLIE D. GREENBERG, Duke.

DEMONSTRATIONS

Bacteria leaf nodules of tropical trees. H. J. HUMM.

Specialized "home-made" physiological apparatus. H. D. BRUNER.

Determination of tissue water by toluene distillation. A. T. MILLER, JR.

Some Indian relics found in western North Carolina.—S. O. TRENTHAM.

Test tube aquaria. J. P. GIVLER AND A. D. SHAFTESBURY.

Plastic reproduction of marine animals. H. F. PRYTHERCH.

Decomposition of cellulose by chytrids. ALMA V. WHIFFEN.

An apparently rare lichen from North Carolina. L. A. WHITFORD.

Action of cilia under dark field. J. N. COUCH.

The continuous extraction of small amounts of quinine from blood. J. C. ANDREWS AND B. D. WEBB.

An experimental tannery in operation. Sponsored by the Rockefeller Foundation.

A living plant of Shortia galacifolia and a number of flower paintings, and also a collection of old botanical books. Botany Department. U. N. C.

NORTH CAROLINA SECTION OF THE AMERICAN CHEMICAL SOCIETY

The determination of ionic entropies by E. M. F. measurements. H. D. CROCKFORD AND H. A. BERNHARDT, U. N. C.

The photolysis of acetaldehyde in intermittent light. W. L. HADEN, JR., E. P. H. MEIBOHM, AND O. K. RICE, U. N. C.

The photolysis of azomethane. C. V. CANNON AND O. K. RICE, U. N. C.

Equilibrium moisture sorptions for three typical high polymer films. S. E. SMITH AND V. L. SIMRIL, U. N. C.

The activity coefficients of sulfuric acid in aqueous ethyl alcohol solutions. H. D. CROCKFORD AND S. A. WIDEMAN, U. N. C.

The colorimetric determination of cerium. E. C. MARKHAM AND F. T. LENSE, U. N. C.

Absorption studies in quinine administration to dogs. G. C. KYKER AND B. D. WEBB, U. N. C.

Structural activity of alcohols. NEVIL ISBELL, Wake Forest.

Some new N'-isocyclic sulfanilamides. J. W. DUCKETT, U. N. C.

Recent advances in the vapor phase fluorination of organic compounds. L. A. BIGELOW, N. FUKUHARA, E. H. HADLEY, AND D. S. YOUNG, Duke.

The oxygenation of di-isobutylene at elevated temperature and pressure. R. W. BOST AND L. B. LOCKHART, U. N. C.

Friedel-Crafts reaction and Fries shift with some nitro compounds. FRANCES BROWN, Duke.

Ketene in the Friedel-Crafts reaction. II. Use of mixed acetic anhydrides. J. W. WILLIAMS, Y. J. DICKERT, AND J. A. KRYNITSKY, U. N. C.

Identification of amides by means of mercury derivatives. J. W. WILLIAMS, ROBERT S. LEOPOLD, AND W. T. RAINEY, U. N. C.

Kinetics of the mutarotation of glucose. D. G. HILL AND H. E. DYAS, Duke.

HIGH SCHOOL SCIENCE TEACHERS MEETING

A report of the work to date of the National Committee on Science teaching. C. E. PRESTON, U. N. C.

Projects in household chemistry. ISABEL MILLER, Dorland-Bell, Hot Springs.

The heredity unit in high school biology. DOROTHY WILSON, Durham.

Free aids for the science teacher. H. J. DAVIS, Williamsburg, Virginia.

The Junior Academy of Science movement as worked out in Pennsylvania. JANET GIFT.

Open Forum on textbook selection.

HIGH SCHOOL SCIENCE CLUB SPONSORS MEETING

Cooperation between science clubs of the state. H. J. DAVIS.
Report concerning the Phy-Chem Club of the Durham High School. B. G. STEWART, Durham.
The bird study class at Reidsville. RUBY M. WILLIAMS, Reidsville.
The camera club. D. F. KELLER, Salisbury.
Open Forum on club activities.

Relation of the Chemical Industries of North Carolina and of Adjoining States to the National Defense. E. E. RANDOLPH.

The chemical industries of North Carolina and of adjoining states were built as a rule to produce materials useful for peacetime needs. In a few cases during the first World War plants were built or enlarged to make products necessary for war uses, such as, the nitrate plant and explosive and munitions plants at Hopewell, Virginia, and the munitions plant at Old Hickory, Tennessee. As soon as the war was over these plants continued to manufacture chemical products useful for peacetime requirements or were so changed as to make entirely different products. Such was the case in the transformation of the munitions plant at Old Hickory, Tennessee, into plants equipped to produce rayon, cellophane, and plastics. Two huge explosives plants have recently been completed in Virginia and in Tennessee, specifically to make explosive materials for the present emergency. After the war both of these plants may continue to manufacture explosives for peacetime development use or they may be re-equipped to produce other materials suitable for peacetime use. Thus considerable flexibility is possible in certain types of chemical production plants.

It is my purpose to indicate that the varied chemical products now manufactured in this area are necessary in normal life of our people and much more necessary in case of war and that many of our plants can readily be adapted to manufacturing war and defense materials. North Carolina's list of chemical industries includes:

1. Over 70 plants producing mixed fertilizers amounting to almost $\frac{1}{7}$ of the amount produced in the United States. Many of the larger companies have plants to manufacture their own sulphuric acid, the concentrated form of which is necessary in processing gun cotton and smokeless powder.

2. Five large pulp and paper plants. One of these plants produces all the cigarette paper made in the United States. It is almost pure cellulose which could be nitrated into explosives. Another one of these

plants is among the largest pulp and paper mills in the country. It processes over 1000 cords of wood per day, yielding about 500 tons of pulp per day. Every type of paper is produced in these mills from Kraft paper and boards to the highest grades of bond paper. The recovered by-products, such as turpentine and tannic acid, are very important materials.

3. More than 18 million dollars worth of leather is made in our tanneries per year.

4. One of the largest aluminum plants in the United States, located in North Carolina, is now working at high speed to produce much of this metal almost exclusively for military use. Just across the line in Tennessee another large aluminum plant is also engaged on war production work. Approximately one-third of the aluminum produced in the country comes from these plants. The importance of this material for war purposes may be judged from the fact that the possibility of purchasing kitchen utensils of it is now strictly limited.

5. It is of general interest that the only plant in the world for extracting bromine from sea water is near Wilmington in this state. This plant also cracks alcohol and makes with this bromine Ethyl-di-bromide and also an additional product, Ethyl-di-chloride, both of which are used in anti-knock materials for better engine performance.

6. No problem is more vital in war-time than an adequate supply of suitable food. Oils and fats constitute one of the prime essentials of foods. Since Dr. Wesson's famous discovery in 1890 an increasing demand for vegetable oils and fats has been felt. For 50 years therefore artificial fats have supplemented the supply of animal fats in human food.

In war times such demands are especially great. Over 50 crude oil mills in this state are engaged in processing cotton seed and soy beans for this purpose. One refinery in this state can refine and hydrogenate much of this oil and convert it with animal fat into nearly ½ million pounds of margerine per day. The value of this crude oil and meal made in this state is between 16 and 20 million dollars per year.

7. One of the most modern rayon plants is located near Asheville. Within a radius of 300 miles from Asheville as a center are located 12 standard rayon plants producing more rayon than all the remainder of the country put together. The importance of this material is increasing since it is becoming more difficult to obtain real silk and also because the production of cotton may be curtailed for lack of man power and the large amounts of cotton which may be required to produce explosives.

8. Other important chemical products of the state include: fish oil and scrap, oxygen, carbon dioxide, nearly 4 million dollars worth of manufactured gas, tanning materials, textile chemicals, soap, paints and varnish, lime, rubber goods (new plant at Waynesville), shoe polish, disinfectants, boiler compounds, heavy and fine chemicals, talc, fireworks, grease, insecticides and sprays, turpentine, and naval stores.

Important chemical products manufactured in adjoining states include: plastics, rayon, cellophane, iron and steel, paper, explosives, greases, cosmetics and toilet preparations, paints and varnishes, sugar, matches, heavy and fine chemicals, flavoring extracts, tar, pitch, turpentine, cement, edible oils and fats, copper, non-ferrous metals and alloys, salt, alkalies, compressed gases, peanut oil and butter, special alloys, and glass.

There are in these adjoining states 9 pulp and paper plants, 3 cellophane plants, 7 rayon plants, 1 sugar refinery, 1 match factory, 1 aluminum plant, 5 iron and steel plants, 1 plastics plant, 4 cement plants, 4 compressed gas plants, 3 vegetable oil refining, hydrogenating and processing plants, 2 modern contact sulphuric acid plants.

An example may illustrate how cosmopolitan are some of our chemical industries. A large tannery in Asheville obtains its tannin from chestnut oak bark from various sections of Western North Carolina and from chestnut wood extract, a by-product from one of our paper mills, quelracho extract from South America, cutch extract from the Dutch East Indies, tara wood extract from Chile, wattlebark extract from South Africa, myrobalan from India, sumac from Sicily, and various synthetic tannin materials. In finishing the leather use is made of Newfoundland cod oil, neat's foot oil, mineral oil, sugar, Epsom salts, borax, sulphuric acid, sodium acetate, sodium chloride, sodium carbonate, beef tallow, wood grease, moellan degras, paraffin wax, cerise wax, petrolatum, and sulphonated oil. This company produces about 5 million pounds of leather per year. It specializes in high grade belting leather for prime movers and machinery but it also makes high grade leather for other uses. It now has a contract with the Navy.

Another example of the magnitude of some of these industries is the plant of the Champion Pulp and Fiber Company at Canton, North Carolina. It consumes daily from southern sources:

Pulpwood	1,000 cords
Coal	700 tons
Lime	50 tons
Sulphur	15 tons

Other chemicals ..	5 carloads
Electric power	22,000 K. W.
Steam	20,000 H. P.

It produces daily for national and export markets:

Chemical pulp	500 tons
Paper	230 tons
Board	80 tons
Tannic acid	100 tons
Caustic soda	30 tons
Adhesive extract	20 tons
Talloil	10 tons
Turpentine	300 gallons

The value of the chemical plants I have mentioned is enormous. At least ten million dollars must be spent to build and equip a standard rayon plant. More than one of the plants I have referred to, along with its equipment and holdings, are valued at more than 50 million dollars each. During the years 1937 and 1938 companies bought many thousands of acres of forest land in the South and built 16 large pulp and paper mills at a cost of over 100 million dollars.

There are already in the area in and adjoining North Carolina many important chemical industries actively producing many things for human comfort and progress. In case of national need many of these plants could intensify their output or could be adapted to make other necessary products for the protection and benefit of people under stress. For example, rayon plants might be adjusted to nitrate cellulose as well as they now xanthate or acetylize it. Our chemical industries in this area with their vast wealth of equipment, like our people, are ready to serve our country for its peacetime requirements or, if compelled to, attempt to meet the requirements of war.

Experimental Study of Group Panic. JOHN R. P. FRENCH, JR.

Stemming from an interest in crowd psychology, this experimental study was designed to discover some of the determinants of the behavior of interacting individuals in emotional situations. The specific purpose was to study the differences between two types of groups—organized vs. unorganized—in a situation producing fear. Eight organized groups composed of athletic teams were compared with eight unorganized groups composed of students who were not acquainted with one another. Each group contained six members.

After a 45 minute frustration session produced by working on insoluble

problems, each group was left alone in the experimental room and instructed to fill out a questionnaire. Both doors to the experimental room were locked without the subjects becoming aware of it. Presently wood smoke was made to seep under one of the locked doors and into the room. After the group discovered the smoke, a fire siren was sounded in a distant room. Thus the situation had the appearance of a dangerous fire. Data on the behavior of each group consisted of descriptive protocols by two observers stationed at one-way screens, descriptions written afterward by the subjects, and phonograph recordings of the verbal behavior.

The behavior of the groups varied from genuine panic to fairly complete skepticism or belief that the situation was a hoax. However, all members within a group tended to react in the same way so that the variability within the groups was significantly less than the variability among groups. The interaction of differing individuals within a group produced a definite group atmosphere which largely determined the reactions of all members of that group.

The organized groups were definitely more frightened than the unorganized groups because: (1) the members exhibited more social freedom and interdependence of behavior which led to more social facilitation and circular social stimulation; (2) they were more frustrated in the previous situation; (3) fewer members were currently taking courses in psychology and hence they lacked one possible frame of reference by which to judge the situation; (4) two of the organized groups were more suggestible and less critical due to less education and more submissiveness to the prestige of the experimenter. The similarity of these results to Cantril's study of the panic caused by the Orson Welles broadcast of the invasion from Mars proves the fruitfulness of an experimental approach to crowd psychology.

Psychology of Phobias. ERWIN STRAUS.

Phobias, like many other psychopathic phenomena, interest the physician primarily as deviations from the average, but they interest psychologists as a means of investigating the norm itself. The observation of quite a number of cases proves that not all patients belong to a type of timid persons. Fear may appear only within typical situations. The patients, although recognizing that their fears have no actual basis, can nevertheless give no explanation for their behavior. Their inside does not at all protect them against the overwhelming power of the attack; but certain "tricks" may help them as well as small seemingly

meaningless changes of the external situation. A thorough analysis of the phenomena shows that explanations usually given, such as those based on the scheme of conditioned reflexes or on subconscious motives favored by psychoanalysis, are insufficient. The attack of fear is related to a physiognomical experience. Therefore, phobias point to the general problem of the physiognomical and of the physiognomy of space in particular. A better psychological understanding may provide the more successful psychotherapy of phobias; moreover, it may contribute to a comprehension of many kinds of normal behavior of individuals as well as of groups.

Some Early Human Embryos with Particular Reference to the Prochordal Plate. W. C. GEORGE.

The report describes a well preserved human embryo estimated to be approximately 19 days fertilization age. The embryonic disk measures 1.01 mm. long (1.16 mm. straightened) by 0.83 mm. broad inside the amnion. The middle third of the disk presents a medullary groove, the caudal one-fourth a primitive groove.

The primitive pit continues cephalically into the notochord and throughout its length as the chorda canal. The floor of the canal has disintegrated throughout one quarter of its length.

Cephalad to the notochord and continuous with it is an axially located mass of thickened endoderm which extends through 120 microns. This is the prochordal plate. It has a deep groove on its under surface. An irregular space extending throughout its length appears to be continuous with the chorda canal.

Other embryos of comparable age described by Hill and Florian, Rossenbeck, and Heuser have prochordal plates. In other vertebrates similar structures have been found to give rise to the head cavities, when present, and to most of the head mesenchyme, and are supposed to be homologous to the most anterior dorsa-lateral evaginations from the archenteron of amphioxus.

The Organic Deposits of the Lower Cape Fear Peninsula. B. W. WELLS AND I. V. SHUNK.

A ridge-like axis of coquina rock (Fort Fisher coquina) extends from Fort Fisher across to the west side and then northward crossing the Inland Canal at the bend.

At the eastern end of the Canal and at Kure's Beach are exposures of a consolidated sand layer (Kure sandstone), black in color, containing

15.5% organic matter. At both sites this layer is overlain unconformably by semi-consolidated sand (Castalia sand) with pollen bearing organic matter (up to 27%) occurring locally, indicating these areas to have been former lily ponds. Forty per cent of the pollen is from the genus *Ilex*. At both sites a third layer is found unconformably burying the lily ponds. This is believed to be made of sand washed over the earlier strata from the nearby sands left by an ancient shoal. This layer shows only a superficial thin humus content.

In the shallow basin between the two sites mentioned, an extremely interesting peat deposit was found exposed on the strand ¼ mile south of the Breakers Hotel. This was a peatty deposit 4 in. thick, made up wholly of matted leaves and twigs. Many of these leaves were pliable and light green. This leaf mass lay directly on sand and was covered by 16 in. of compact black peat. *Persea* (red bay) stumps and roots were abundant over the surface. The green leaf pigment quickly faded in light, was soluble in alcohol, and similar to chlorophyll in the spectroscopic test. A hurricane must have been involved in the formation of this deposit.

The stump layer was exposed only at low tide and since *Persea* is an upland bog tree the ocean must have been at least 3 feet lower than at present, to have made its growth possible. Since the ocean has in recent millenia been rising so slowly as to simulate stability it is believed that the leaf deposit with its undestroyed chlorophyll must have been there for at least 5000 years. Other evidence indicates it to be much older than that.

The Volcanic Eruption in North Carolina, December, 1811. A. H. GODBEY.

A letter written January 10, 1812, by John Clarke Edwards, a mineralogist hunting the mountains for cobalt, was published in the *Raleigh Register* on February 7, 1812; referred to in *Register* February 14, when the *Register* gives a column of citations extending from Charlestown, N. H., to Chickasaw Bluffs on the lower Mississippi, 176 miles south of the mouth of the Ohio River. Later a few more citations; a long letter from Mecklenburg County was not published, much to our present regret. War with England was the supreme interest.

Three weeks earlier Edwards had written another letter from Asheville, dated December 19, three days after the great quake began (December 16, 2 A. M.). That it was synchronous with the beginning of the great New Madrid quake nobody then knew; both began with in-

credible crashing thunders. Volcano St. Vincent in West Indies burst forth at the same time, and the first great shock at Caracas, Venezuela. But the most fearful destruction at Caracas was on the following March 26, 4:07 P. M.

William Leigh Pierce wrote three letters of his personal experiences to different papers. One of them was republished with two other letters at Newbury Port, Mass., 1812. The Philadelphia *Aurora*, February 22, 1812, published a column of extracts from a diary letter of a gentleman in the New Madrid area, beginning December 16, last citation dated December 28. There had been 67 shocks in 12 days. We shall never know how much we have lost through editorial failures to publish.

Because the tremendous economic destruction was in New Madrid Province (which included the present Arkansas) and West Tennessee, a considerable bibliography has grown up. The State Historical Society of Missouri had 23 volumes in its bibliography in 1913; it had 37 in 1936. But I know of none for North Carolina. We also have an authoritative geological study for the New Madrid area. Should not a like conspectus of extant materials be made for North Carolina? The old Mecklenburg letter above mentioned hints that more such source narratives may still exist.

*Human Plasma Lipids and Proteins in Filtration through Membranes of Graded Permeabilities.** CAMILLO ARTOM AND JOHN FREEMAN.

The present experiments are a part of a more extended study undertaken to secure additional information on the associations between proteins and lipids, especially phospholipids, in human plasma. The plasma has been filtered through collodion acetate membranes of various permeabilities under a positive pressure which never exceeded 1.5 atmospheres.

Lower proportions of proteins than of total phospholipids are retained by the membranes, only negligible amounts of the latter being present in filtrates which contain about 30% of the plasma proteins. These results may be compared with those of Page[1] who found that the urine of nephritic patients is practically free from phospholipids.[2]

The separate determination of choline phospholipids (lecithins plus

* Aided by a grant from the Dazian Foundation for Medical Research.

[1] Page, I. H., Amer. J. Med. Sc. **192**: 217 (1936).

[2] The discrepancy between our data and those from Went and Goreczki (Biochem. Zeitschr. **239**: 441, 1931) is perhaps due to the higher filtration pressures they used (from 25 to 125 times as great as the highest we used).

sphingomyelins) and cephalins shows that, using the less retentive membranes, cephalins are retained to a less extent than proteins and proteins less than choline phospholipids. A similarly greater permeability of the membranes toward cephalins than toward choline phospholipids has also been observed in cephalins in experiments in which colloidal solutions of egg phospholipids (without proteins) have been filtered through rather permeable membranes. By increasing the retentiveness of the membranes, their permeability toward plasma cephalins decreases rapidly, practically all cephalins being retained by membranes retaining about 70% of the plasma proteins.

The behaviour of total cholesterol approximates that of choline phospholipids, whereas the permeability of the membranes for total fatty acids is intermediate between that for proteins and that for total cholesterol and choline phospholipids.

A consideration of previous and present results suggests that in human plasma the lipids and proteins are associated through loose linkages which are easily split during the filtration either by the filtration pressure or by differential adsorption to the membrane or to the proteins concentrated on the filter.

The Ascorbic Acid Content of Turnips. W. T. BURNETT AND G. H. SATTERFIELD.

Data were given on the ascorbic acid content of the greens of five varieties of turnips grown during the summer of 1940 in the greenhouses of the North Carolina State College Agricultural Experiment Station and of the greens and roots of seven varieties grown during the fall in the college gardens.

The method used for the determinations was a modification of the Bessey-King titration method, that is, extraction with a mixture of 8% acetic acid-4% metaphosphoric acid and titration with 2–6 dichlorophenolindophenol.

The amount of ascorbic acid in all of the fall varieties, with a few exceptions, increased progressively as the plant matured. Marked variations were noted between samples of the same variety when analyzed under identical conditions.

No correlation was found between the variety and the ascorbic acid content of either the roots or the greens. The portion immediately under the epidermis of the root contained from 1.5–2 times the amount in the inner portions.

Cooking and standing at room temperature exerted a marked influence upon the ascorbic acid content. Turnips cooked one hour averaged

19.4 mg. per 100 grams of sample. On standing at room temperature a loss of approximately 33% occurred.

Some Observations on Dark Adaptation and Vitamin A Metabolism. W. J. DANN AND M. YARBROUGH.

Dark adaptometer readings and blood carotene and vitamin A levels have been determined on a test group of 16 subjects and on 154 of a nutrition survey group. Blood tests alone were made on 43 additional nutrition survey subjects. The results obtained for the test group correspond with those reported by other investigators for normal subjects. The blood-vitamin-A mean for the nutrition survey group was found to be lower than the normal values obtained by other investigators, while 96.7 per cent of the dark adaptometer readings were normal according to the criterion of Hecht and Mandelbaum, or 98 per cent according to the mathematical test suggested.

Correlation coefficients were calculated from the results obtained from the 154 nutrition survey subjects. No correlation was found between dark adaptometer readings and blood carotene values, or between dark adaptometer readings and blood vitamin A values.

From the evidence presented, it appears that the Hecht and Shlaer dark adaptometer is not a reliable instrument for measuring mild avitaminosis A, and that the blood test offers a more promising means for determining the vitamin A status of an individual.

Some Nutritionally Important Minerals in the Scuppernong Grape. MARGARET KRAMER AND G. HOWARD SATTERFIELD.

The edible portion of the scuppernong grape was analyzed to determine the amount of certain minerals present. The following percentages were found: expressed in terms of ash, calcium oxide, 5.5741%, magnesium oxide, 3.195%, iron oxide, 1.644%, aluminum oxide, 3.999%, chloride, 2.39%, manganese oxide, trace; expressed in terms of dry weight, calcium oxide, .06450%, magnesium oxide, .03728%, iron oxide, .0191%, aluminum oxide, .04667%, chloride, .02790%, manganese oxide, trace, phosphorous pentoxide, .1429%; expressed in terms of fresh weight, calcium oxide, .01159%, magnesium oxide, .00556%, iron oxide, .00291%, aluminum oxide, .007081%, chloride, .004233%, manganese oxide, trace, phosphorous pentoxide, .0216%.

Cytological Studies in the Oryzeae and Zizaneae. WALTER V. BROWN.

The 4 genera, *Leersia* and *Oryza* of the Oryzeae, and *Zizania* and *Zizaniopsis* of the Zizaneae were studied for chromosome size and numbers.

The basic number for the Oryzeae as determined from 3 species of *Leersia* and 2 species of *Oryze* is 12. The basic number in the Zizaneae is perhaps 6, *Zizania aquatica* having 2n = 30 while *Zizaniopsis miliacea* has 2n = 24.

A Bog Community in Southeastern North Carolina. MURRAY F. BUELL AND R. L. CAIN.

The community considered is that community on peat soil where *Chamaecyparis thyoides* (Southern White Cedar) is the dominant feature. This community has its origin on open peat soil among a low herbaceous growth of grasses, sedges, and sphagnum. Peat soils in this region are normally clothed in a luxuriant ligneous vegetation. For the creation of a satisfactory seed bed for the White Cedar some catastrophic event such as fire or the sudden receding of impounded waters is necessary. Fire at a time of a high water table seems the most likely natural phenomenon. Pocosin shrubs and vines of Smilax offer severe competition to a young white cedar forest. This is more especially true when the cedar does not originate as a dense stand. Toward maturity of the white cedar forest broadleaf evergreens invade the forest. Of these *Persea pubescens* predominates. These broadleaf evergreens that invade the cedar forest represent the climax forest on peat soils of southeastern North Carolina.

The Role of Chytrids in Cellulose Decomposition. ALMA J. WHIFFEN.

Of five species of chytrids commonly found in the soil, two species, *Rhizophidium carpophilum* and *Rhizidiomyces apophysatus*, lack the ability to decompose cellulose but *Entophlyctis* sp., *Rhizophlyctis rosea*, and *Nowakowskiella elegans* are shown to be cellullose-decomposing organisms. Decomposition of cellulose by *Rhizophlyctis rosea* is superior to that of cellulose-decomposing bacteria and equal to that of *Actinomyces*. Such filamentous fungi as species of *Aspergillus*, *Trichoderma*, and *Fusarium*, however, are much more active in cellulose decomposition than *R. rosea*. A survey of the literature reveals that the role of chytrids in the work of cellulose decomposition in the soil has not been previously recognized and is now reported for the first time.

Heterochromosome Formation in Benzoin aestivale. HENRY W. JENSEN.

During microsporogenesis in *Benzoin aestivale* a medium sized pair of chromatids give evidence of being heterochromosomes. Not only is there a difference in structure, but the two units differ in behavior.

Because one unit is extruded into the cytoplasm in approximately 50% of the PMCs. the pollen of this species is calculated to be of three types, namely; one quarter deficient by one chromosome, one half containing the smaller element of the heterochromosome pair, and one quarter containing the larger element of the pair. Since the haploid number of the species remains twelve, the deficient quarter of the pollen is assumed to be largely non-functional. The significance of this case in a scheme to suggest the origin of heterochromosomes is discussed, particularly in relation to *Ilex opaca* and a plant of *Silene vulgaris*. The description of a heterochromosome pair in this practically dioecious species of *Benzoin* is not to be taken as a claim for the presence of sex chromosomes.

The Cause of Low Water Loss from Cacti and Other Plant Materials. PAUL J. KRAMER.

The resistance of cacti to desiccation has sometimes been ascribed to the high imbibitional forces of the colloidal material occurring in the stems. Cacti have a low osmotic pressure, however, and since imbibitional and osmotic forces tend to come into equilibrium in any given tissue it seems unlikely that normal cactus tissue ever has a very high imbibitional force. It seems more likely that the resistance to water loss is dependent on the heavy layer of cutin covering the epidermis. Experiments were performed to determine the importance of this cutin layer in retarding water loss. The cutin was scraped from certain stem segments and left intact on other similar segments. All segments were weighed, stored in a large desiccator over sulphuric acid, and reweighed at intervals. After two months the control segments were at 80 to 90 per cent of their original weight, while the segments from which the cutin had been removed had dried down to 10 to 15 per cent of their original weight. Two of the unscraped segments produced new shoots while in the desiccator. Evidently the resistance to water loss of cacti is chiefly dependent on the heavy layer of cutin rather than any water-holding power of the colloidal cell contents.

The rate of water loss of peeled and unpeeled potato tubers stored in a desiccator was also compared. After 90 days peeled tubers had dried down to 10 to 20 per cent of their original weight while unpeeled tubers weighed 75 to 85 per cent of their original weight. The unpeeled tubers all produced sprouts. The corky layer covering potato tubers seems to be as effective in preventing water loss as the cutin layer covering cactus stems and potato tubers are as resistant to desiccation as segments of cactus stem.

New and Rare North Carolina Algae. L. A. WHITFORD.

Nine new or rare forms of fresh-water algae were illustrated by means of lantern slides and briefly described.

In the Myxophyceae a species of *Dichothrix*, symbiont in an ascomycetous lichen (*Lichina* ?), was described. *Phaeosphaera gelatinosa* W. and G. S. West (Chrysophyceae) is reported from North America for the first time. The following new forms of Chlorophyceae were described; two species of *Chlamydomonas*, an apparently new genus near *Tetrallantos*, a *Zygnema*, and a species and a variety of *Micrasterias*.

Micrasterias floridensis Salisbury is reported for the first time outside Florida.

Structure and Action of Cilia in Aquatic Fungi. J. N. COUCH.

By using special staining technic and dark field illumination it has been found that the cilia of the spores of the Chytridiales, Blastocladiales, and Monoblepharidales have a long thick basal part and a thin short lash or tail piece. This tail piece is invisible with ordinary staining or with transmitted light. In *Rhizidiomyces apophysatus* and a polycentric genus related to *Rhizidiomyces* the single anterior cilium shows numerous short lateral "hairs," the "tinsel" cilium of Vlk and others. In the biciliate Phycomycetes as *Olpidiopsis, Myzocytium, Pythium*, and *Saprolegnia* the posterior cilium has a whip-lash on the end just as in the chytrid spore, but the anterior cilium has a blunt end with short lateral hairs or tinsels. Sometimes the tinsels are very regular and uniform in their arrangement; at other times the arrangement is irregular.

Dark field studies have shown that the spore of the chytrids, *Monoblepharis* and *Allomyces*, is propelled by the oscillation of the cilium in one plane in respect to the spore. The spore may swim in a wide circular orbit or in a straight line not rotating on its axis; or in some genera it may swim in a straight line rotating on its axis; or it may swim in a spiral path rotating on its axis. When the spore rotates on its axis, the cilium presents an alternating single and double image, the single image being formed when the cilium is oscillating in a plane vertical to the observer and the double image being formed when the cilium is oscillating in a plane horizontal or diagonal to the observer.

Dark field studies have shown that the spores of *Saprolegnia* in the first stage swim with one cilium in front, the other directed to the side and backward. Both cilia are attached close to the anterior end of the spore and are active in propelling the spore, the anterior cilium oscillating in one plane and the posterior one oscillating in a different plane. In

the second stage in *Saprolegnia* and in *Myzocytium*, *Resticularia*, *Pythium*, *Achlya*, and *Dictyuchus* the two cilia are attached laterally and both are active in propelling the spore.

Judging by the number of cilia on the spore, the mode and position of attachment, the structure and action of these organs, there are three distinct lines of development in the aquatic Phycomycetes in the forms so far studied: (1) the true chytrid line with a single posterior whip-lash cilium; (2) the *Rhizidiomyces* line with a single anterior tinsel cilium; (3) the *Olpidiopsis*, *Lagenidium*, *Saprolegnia*, and *Pythium* line with an anterior tinsel cilium and posterior whip-lash cilium. These observations thus confirm and extend the phylogenetic ideas concerning the lower forms as expressed by Scherffel, Sparrow, Weston, and Karling.

Starch Storage in Roots of a Plant of Echinodorus radicans. WALTER V. BROWN.

A plant of *E. radicans* (Nutt.) Engelm. that had been kept in the greenhouse for a year produced swollen lateral roots. The stele and endodermis are very conspicuous. The cortex of the swellings is thick, the cells of which are packed with large starch grains. Only small grains are found in the stele.

Patination as a Chronometer in Archaeology. A. H. GODBEY.

Archaeologists working in the Orient began studying patination in Palestine, North Arabia, Egypt, and North Africa 90 years ago. Twenty important studies, totaling hundreds of pages, have been published. Not knowing these, students of Amerind archaeology err notably. The polished casing-stones on the upper third of the pyramid of Khefren remain as placed 5100 years ago. In that time a thin chemical patina has formed a basis for chronometry of all aerial patination in that region. But in a dry wady near Silsileh, 30 miles north of Assouan, a Pharoah inscription of 2100 B. C. is as fresh as if cut yesterday; no patination in 4000 years. But it is cut across petroglyphs of animals that vanished from Egypt ages ago; and these are patinated like the surface of the boulder, ages older than the Pharoah inscription.

All chemical patination results from the certainty that silicon will combine with any alkali or any mixture of alkalies in the presence of water, more rapidly with mixtures. Twenty-four chemical compounds of silicon are already listed. Free silicon is never seen in the field. A granite containing acid feldspar cannot be disintegrated by water; one with basic feldspar can be. Both kinds exist in North Carolina.

No acid combines with silicon except hydrofluoric. A. R. Kelly

working in the Ocmulgee National Park at Macon, Georgia, has found the most highly disintegrated chalk-white flints yet reported in America. But he has ruined his chronometrical guesses and misled his readers by assuming that humic acids could have produced those results. But it has been known for 100 years that humic acids stain everything, including patinas, a dark brown, but cannot produce a patina. Alkalized silicas are always white.

The German Imperial Physical-Technical Foundation has for 15 years been studying the patination of glacial boulders in North Germany, to learn something of the duration of each glacial period, and glacial interval. The lime in that soil produces 1 mm. or $\frac{1}{25}$ of an inch of penetration in 8000 years. Like penetration in soils with more or less lime, we have to determine likewise penetration by other alkalies. For the geological chemist, each soil is a special problem.

The German Foundation also finds that a quartzite composed of nonsiliceous materials cemented together by siliceous infiltrations, may have the original material dissolved out by some acid element, leaving a siliceous sponge. English and French observers notice that a new material may be deposited in that sponge. St. Mary's School District in Orange County, North Carolina, has abundance of such quartzite in the vitrified volcanic ash known as taconite, a favorite material for Amerind artifacts. A collection of many thousands of tools and chips from the same surface shows all stages, from no patination to complete disintegration; thousands of years of difference in age. Each soil presents a separate time problem.

Manganese in North Carolina. T. G. MURDOCK.

Manganese occurrences in North Carolina are widely scattered throughout the state; include both the more common and rarer minerals; have been mined on a small scale; and, are found in both older crystalline rocks and Cambrian sediments. The latter are considered the most important; are located in Cherokee, Transylvania, Madison, and McDowell Counties, and apparently bear certain resemblances to commercial deposits in neighboring states where the ore is found at or near the contact ot the Shady dolomite and underlying Erwin quartzite. Recent developments at two properties show evidence of similarity. Managanese is found associated with magnetites of Ashe County, particularly at Piney Creek Mine, and with iron ores in other localities. Other deposits include those in the older crystallines such as in Surry County, a source of previous commercial production; in Alleghany

County where the silicates alleghanyite, rhodonite, and tephroite occur; and, in Wake County where a large tonnage is indicated near the surface. A belt of manganiferous slates, remarkably persistent along the strike extends from Catawba County southwestward into South Carolina. A similar occurrence is found in Clay County. The deposits in the older crystallines appear to come from weathering of manganese silicates, particularly spessartite, and in some cases unaltered silicate is found practically at the surface. These deposits are not expected to continue beneath the weathered zone. Should ore dressing technology develop sufficiently, some of these deposits might have commercial possibilities, especially for making manganese sulphate fertilizer, for which a commercial plant is in experimental operation in Raleigh.

Mineral Resources of the Southeastern States. G. W. CRICKMAY.

This paper is a general consideration of the mineral production of the southeastern states, particularly promising fields of research are those which:—

(1) Involve possible domestic utilization of southern minerals both in the mineral industries (whiteware) and in industry in general (chemical lime).

(2) Development of strategic and critical minerals (manganese, aluminum).

Consideration is given the advantages of organization of southeastern geologists to cope more effectively with regional problems.

Well #2, Camp Davis, North Carolina. WILLARD BERRY.

Well Number 2 at Camp Davis began in surface sands and muck and penetrated the following section tentatively correlated as follows: surface to 111 feet, Pleistocene sediments with Pamlico fossils 73 to 83 feet, 111 to 135 Miocene (Duplin); 135 to 148, Miocene (Trent ?), and 148 to 176, Eocene (Castle Hayne). The material down to 75 feet has no lime, 75 to 83 feet, 24% lime, and then no lime to 111 feet. The Miocene runs 44% limestone, the Trent (?) 53% limestone, and the Castle Hayne 71 to 95% limestone. The fossils encountered were Foraminifera, Ophuiroid joints, Comatulid joints, Echinoid spines, Bryozoa, Gastropod casts, Arca, Oyster fragments, and Ostracods. Minerals encountered were quartz, clear and frosted, glauconite, magnetite, mica, and calcite.

Limonite Pseudomorphs after Pyrite in the Chapel Hill Area. ROBERT NEUMAN.

Several deposits of limonite pseudomorphs after pyrite have been found west of Chapel Hill, N. C. They are cubes ranging from $\frac{1}{16}$ to $3\frac{3}{4}$ inches in size. The mineral content is not wholly limonite; pyrite, hematite, and other minerals are found.

Further investigation will be conducted at the Geology Department of the University of North Carolina.

Effects of Varying Amounts of Rainfall upon Topography as Illustrated by the Tradewind Climate of the Hawaiian Islands. G. R. MACCARTHY.

While intermediate types are common, most of the valleys and "gulches" of the Hawaiian Islands fall into one or another of two main types. In the more humid (windward) portions of the islands, large flat-floored, amphitheatre-headed valleys are common. Some of these are of enormous size and end headward in nearly vertical walls resembling the head walls of glacial cirques. In most cases these head walls are fluted vertically. In the less humid (leeward) portions of the Hawaiian Islands this type of valley is almost unknown, the typical form being the deep, narrow, "V-shaped" gulch resembling in cross-section an ordinary erosional gully. None of these V-gulches contain permanent streams, while all of the amphitheatre-headed valleys do. While several suggestions as to the origin of the amphitheatre-headed valleys have been made by different people, the exact mechanism by which they are formed is not very well understood.

The higher peaks of the Hawaiian Islands (Haleakaka, Mauna Kea, Mauna Loa, etc.) stand well above the general level of the trade wind clouds so that while annual precipitations of 300 or more inches per year may be recorded on the mountain flanks, the summit areas--being above the cloud level—may have annual precipitations of only 30 or 40 inches. Hence vegetation is scant on these higher peaks, and erosional activity at a minimum, the deep gulches rarely extending much above the main cloud level.

*Observations on the Structure of the Blue Ridge in Central Virginia.** ROBERT O. BLOOMER.

Stratigraphic and structural relations in the James River section of Virginia indicate the presence of a buried massif or buttress parallel to the trend of the Blue Ridge. This buried mass accounts for the absence of the Catoctin volcanic series beneath the Unicoi formation. Further-

* Presented with permission of the State Geologist of Virginia.

more the localization of orogenic forces against this mass probably explains the numerous overthrusts in a narrow zone along the southeastern flanks of the Blue Ridge and also the rapid progression in metamorphism from northwest to southeast across the axis of the Buena Vista anticline.

Silurian of Eastern Tennessee. W. F. PROUTY.

The Silurian formations of Eastern Tennessee vary greatly in both character and continuity. In general the formations are better developed and more fully represented toward the north and east. With the exception of the northeast portion of the Cumberland Basin area in the state, the Silurian is confined to formations of Medinan and Clinton age. To the south and west in the Eastern Tennessee area all formations tend to become thinner and more marine in character.

A barrier was functional between the Cumberland and Lenoir Basins in Clinton and Cayugan time and later in Oriskany time but division of the Basins into troughs is not indicated. Throughout much of the northeastern portion of the area thrust-faulting is extensive and repetition of beds by faulting is not uncommon.

Concerning I-normal and H-normal matrices. E. T. BROWNE.

Let A be an n-square matrix whose elements lie in the field of complex numbers. If A is commutative with its conjugate transpose, i.e., if $AA^* = A^*A$, then A is called *normal.* Obviously, any matrix A which is such that A^* is expressible as a polynomial in A is normal. Moreover, it was shown recently by J. Williamson that only such matrices are normal. If f(x) is a scalar polynomial and if H is a positive definite Hermitian matrix such that $A = Hf(A)H^{-1}$, we shall call A *H-normal.* This paper is concerned with a study of such normal matrices, the ordinary normal matrices being called I-normal in contrast with the H-normal matrices.

The Significance of a Critical Ratio (CR). J. A. GREENWOOD.

Let p be the probability that in a normal sample a critical ratio greater than or equal to a preassigned positive number x be attained. It is shown that

(1) If the CR of the first sample is t, $0 < t < x$, there is a unique choice of size of a second sample to be combined with the first, such that the probability of a CR greater than or equal to x for the total is a maximum.

(2) Under these conditions for n samples successively combined, the *a priori* probability of a CR greater than or equal to x for at least one of the sample points is less than np.

A Continuous One-Parameter Family of Plane Curves and some Associated Curves. L. L. GARNER.

The equations:

$$x = a(\sec\theta \pm \tan\theta)\cos t\theta$$
$$y = a(\sec\theta \pm \tan\theta)\sin t\theta$$

where a is constant, t a parameter which varies over the real numbers, and θ is an angle which varies from $-\frac{\pi}{2}$ to $\frac{\pi}{2}$, represents a continuous family of plane curves.

Consider a fixed value of the parameter t. This picks out a particular curve, two points of which, P and $\bar{P}$, called conjugate points, are given for every value of θ. If tangents are drawn to the curve at these points, their point of intersection, V, will generate another curve as points P and $\bar{P}$ move along the original one. Moreover, if normals are drawn to the original curve at the conjugate points, the point of intersection of the normals will generate a third curve.

It is the study of these associated curves in connection with the original family with which the present paper deals.

Changes in Students' Attitudes During Four Years in College. K. L. BARKLEY.

The purpose of the study was to discover the nature and degree of changes in students' attitudes during their four years in college. Scales of the series edited by Thurstone for measuring attitudes toward war, law, God, the church, the constitution of the United States, evolution, and the negro were given five different times, namely, at the beginning and end of the freshman year, and at the end of each of the other three years. The test-retest method was employed; Form A was given first and then Form B in case of the scales for which both forms were available. There was only one form available for measuring attitudes toward the church, hence this one form was used each time.

The results show that there was a reliable change to a more unfavorable attitude toward war in the first year and a trend toward a more favorable attitude during the other three years. Changes in attitude toward evolution were consistently in the direction of a more favorable attitude. The difference between entering freshmen and seniors was reliable. There were no significant changes in attitude toward God and the church. Changes in attitudes toward the law, the Constitution, and the negro were not clearly defined. It appears that the scores on the two forms of these scales may not be comparable.

Change in Personality Trait Ratings during Attendance at College. ROY R. ULLMAN.

As part of a comprehensive testing program conducted over a period of four years at a small private college an attempt was made to determine the extent to which personality traits change during attendance at college The Bernreuter Personality Inventory was administered each year at regularly scheduled times to every student in attendance. Data were obtained from 324 different students classified as follows: (1) 96 freshmen who completed their enrollment, but withdrew before or at the close of their first year. (2) 116 students who completed their freshman and sophomore years, but did not return for the junior year. (3) 58 transfer students for whom ratings were obtained during the sophomore and junior years. (4) 54 students who remained at the college for four years and for whom ratings were obtained each year.

Results were recorded in terms of percentile scores and the means and critical ratios of the differences between the means were computed. In groups two and three, comparisons were made with the scores obtained during the preceding year and with the scores of the freshmen of group one. In the case of the fourth group, the amount of change from year to year and from the freshman to the senior year, was computed.

The results obtained seem to justify the following conclusions:

1. Students who fail or withdraw during their freshman year are less stable emotionally and less well adjusted than those who return to college.

2. There is a statistically significant improvement in personality ratings from the freshman to the senior year.

3. Students with high intelligence ratings score somewhat higher in personality than those with lower intelligence ratings.

4. There seems to be sufficient change in personality from year to year to justify a more careful evaluation of the answers given to the questions in personality scales.

5. Norms should be determined for age and grade levels.

Towards a Definition of Propaganda. E. H. HENDERSON.

Previous definitions of propaganda have disagreed widely and have generally failed to meet the requirements for a good psychological definition. But in the belief that there is a psychological phenomenon called propaganda, and that its essential characters may be formulated, this paper attempts to arrive at such a formulation inductively through examining a fair sampling of published definitions. The points of agreement thus found suggest the following definition: Propaganda is

a systematic effort (hence a method) deliberately initiated in order to compel another to adopt such attitudes or perform such acts as the propagandizer desires adopted or performed, before the victim is able to think critically. Or, more briefly, propaganda is any systematic attempt to inculcate attitudes or to compel decisive action before the victim is able to think critically about the situation.

In justification of this definition, the paper points out that it

(1) Makes propaganda a pressure technique, so that time is "of the essence";
(2) Turns on the relation of the propaganda method to rational activity;
(3) Enables us to make a genuine distinction between propaganda and education;
(4) Enables us better to understand certain familiar facts about propaganda.

Inter-relational Influences of Three Different Adjunctive Stimuli in Punch-board Maze Performance. HALSEY M. MACPHEE.

The purpose of this investigation was to determine how three different adjunctive stimuli (buzzer, electric shock, and "no-signal"), working in combination, would influence human learning performance in a punch-board maze situation in which the subjects were confronted with three possible choices at each choice point, each choice being associated with a different adjunctive stimulus.

Three groups, totaling 108 subjects, learned the maze. The conditions for the groups were: Group I, buzzer-right, shock-wrong, no-signal-wrong; Group II, shock-right, buzzer-wrong, no-signal-wrong; Group III, no-signal-right, buzzer-wrong, shock-wrong. The data were analyzed with reference to the influences of the adjunctive stimuli on the selection of correct responses and the elimination of incorrect responses.

The results showed that differences in maze patterns were more important in determining responses than were the influences of the stimuli. When measures were taken to control the factor of pattern differences and the factor of possible differences in learning ability, the three adjunctive stimuli appeared to exert relatively small but consistently different degrees of influence on learning performance. Considered in terms of *both correct and incorrect responses*, this consistency of influence was shown by the fact that the subjects tended to repeat most often the responses that were directly associated with the buzzer, they repeated

less often the responses associated with the shock, and they repeated least often the responses associated with the no-signal. A possible interpretation of the results is offered in terms of factors of intensity, quality, disruption, and adaptation.

A Preliminary Study of Imitational Learning in White Rats. A. G. BAYROFF.

Untrained white rats were placed one at a time in the rear compartment of the starting box of an underwater discrimination apparatus. In the front compartment was placed, on some trials, a rat which had been trained to take the left turn and, on other trials, one which had been trained to take the right turn. If the rear animal took the turn the front animal did, it escaped from under the water. If the rear animal took the turn the front animal avoided, the former was blocked and had to reverse out of this turn. The only cue the rear animal had as to which turn was correct was the turn made by the front animal.

On the first trials, the rear animals did not follow the front animals. With more trials, the rear animals learned to follow, a few of them doing so by seizing the tail of the front animal.

The Localization of Function in the Cochlea as Determined by the Recording of Electrical Potentials. E. H. KEMP.

Electrical responses from the cochlea of the guinea pig were studied by means of an amplifier, a cathode-ray oscillograph and a wave-analyzer. The guinea pig was anesthetized with dial and urethane, put under artificial respiration and placed in a "sound-proof" room. A beat-frequency oscillator, attenuator and speaker provided tones which were delivered to the ear of the guinea pig through a rubber tube and a speculum which had been sewed into the external meatus. The cochlear response to frequencies of 100, 200, 400, 600, 1,000, 2,000, 4,000, and 6,000 cycles per second was recorded from selected positions on each turn of the cochlea. For each frequency a series of intensities was used and a log response–log relative sound intensity curve obtained. From these curves the relative intensity of sound of each frequency necessary to elicit a response of three microvolts was determined for each recording position. The data obtained make it possible to construct a map of the cochlea which meets the requirements of the place theory of audition, and which confirms a map of the cochlea previously constructed by Culler from data obtained by a somewhat different method.

After-Imagery of Some Color-Blind Observers. J. F. DASHIELL AND CAROLINE C. TAYLOR.

Some twenty students found to be color blind by a rapid preliminary test administered to groups, were more thoroughly examined with the Ishihara tests. Of these some proved to be red-blind, some green-blind, and some both red- and green-blind. They were then guided in observing under experimental conditions their negative after-images to the Munsell hues, Red, Yellow, Green, Blue, and Purple; characterizing the colors of the images by identifying their equivalents in the Munsell color manual.

The after-images of the red-blind and of the red-green-blind were found to depart from the after-images of normal-sighted people by varying within the Y-B dimension only. Those of the green-blind could not be characterized so simply. While their after-images to B and Y approximated those of the normal-sighted, those to P departed slightly in having more yellows than the normals, and those to R and G showed marked irregularities, those to R containing no green component, and those to G showing fewer reds than the normals, some blues, and several gray after-images.

Opportunities for Psychologists in North Carolina. W. MCGEHEE.

An analysis of the activities of psychologists in North Carolina is presented. Attention is called to the fact that, with few exceptions, all psychologists in the state are connected with the instructional staff of colleges and universities. Opportunities for psychological work beyond the confines of institutions of higher learning are described and the failure of psychologists to take advantage of these opportunities is discussed. Causes for this failure are suggested and a program for remedying this condition is proposed.

A Sporozoan Parasite in the Testes of Menhaden. A. B. HARDCASTLE.

Oocysts of what appears to be a new species of coccidium (Genus *Eimeria*), have been found in the testes of menhaden. Study of over a hundred individuals showed an infestation of nearly 50%. All stages of sporogony are present in the testes in great abundance, beginning with the encysted zygote and concluding with the formation of sporozoites. As in the case of previous studies of coccidia parasitic in testes, no other stages could be found, so a systematic study of other organs of the fish host was undertaken in an effort to complete the life cycle. In the epithelium of the pyloric caeca, numerous schizogonic stages and gameto-

cytes were discovered which closely resemble similar stages of other species of *Eimeria*. This, coupled with the fact that no oocysts have been found in the gut, points to the possibility that these may be the missing stages. It is hoped that further study will bring to light a migratory stage by means of which the testes are infested.

The Anatomy of the Gonads of an Ascidian, Styela plicata Lesueur. G. H. TUCKER.

The genital complex comprises a number of compound gonads, each consisting of ovary and testis. The testis is composed of a number of testis follicles, each connected by a vas efferens to a single, elongate vas deferens opening into the cloacal cavity. The ovary is essentially an elongate tube continuous with a short oviduct opening also into the cloacal cavity. The internal wall of the ovary is a germinal epithelium, and the developing ova come to lie outside of it but connected to it by hollow follicular stalks continuous on the one hand with the germinal epithelium and on the other with the outer layer of follicle cells surrounding the ovum; the cavities of the follicle stalks are continuous with the ovarian cavity.

Another Predatory Webspinning Fly Larva. B. B. FULTON.

While investigating the life history of the luminous larva, *Platyura fultoni* Fisher, in the mountains near Glenville, N. C., another web-spinning larva was sometimes found associated with the luminous species. This larva was very active and made a long, winding web consisting of a single main strand supported by numerous lateral strands. The web was not adhesive but when a very small insect touched it the larva would move rapidly to that point and capture the insect by attaching strands of web to it. Insects above a certain size were not attached. A single adult reared was identified by Dr. Elizabeth Fisher as *Neuratelia scitula* Johannsen of the family Mycetophilidae.

BERT CUNNINGHAM, *Secretary.*

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY

October 8, 1940, to May 13, 1941

402nd Meeting, October 8, 1940

R. W. Bost: *Some New Sulfanilamide Derivatives.*
J. N. Couch and W. J. Schoene: *A Fungus that Kills Mealy Bugs.*

403rd Meeting, November 12, 1940

J. C. Andrews: *Chloroform Emulsification as a Means of Protein Separation.*

Henderson: *A New Geometrical Interpretation of Einstein's Special Relativity Theory.* Published in full in this issue.

404th Meeting, December 10, 1940

H. D. Crockford: *Electromotive Force Studies in Aqueous Solutions of Sulphuric Acid.*

G. R. MacCarthy: *Scenery of the Hawaiian Islands.*

405th Meeting, January 7, 1941

R. H. MacKnight: *The Chemical Constitution of Chromosomes.*
W. F. Prouty: *Carolina Bays.*

406th Meeting, February 11, 1941

T. F. Hickerson: *Motion Pictures of Tacoma Narrows Bridge Failure.*
Otto Stuhlman: *The Source of the Aural Harmonics Heard by the Human Ear.*

407th Meeting, March 3, 1941

C. D. Van Cleave: *The Inductive Effect of Several Non-living Tissues upon Isolated Gastrular Ectoderm.*

H. B. Gotaas: *The Natural Disappearance of Bacteria in Air and the Effect of Chemical Disinfection on Air-borne Bacteria.*

408TH MEETING, APRIL 8, 1941

E. C. MARKHAM: *Modern Methods in Micro-Chemistry.*
WITOLD HUREWICZ: *Geometry without Points.*

409TH MEETING, MAY 13, 1941

G. L. DONNELLY AND R. L. HOLMAN: *Sodium Citrate as a Protective Agent against Kidney Injury by Uranium Nitrate.*
A. G. BAYROFF: *Experimental Procedures in the Study of Animal Behavior.*

The following officers were elected for the year 1941–42:

President—A. E. Ruark.

Vice-President—G. C. Kyker.

New members of the *Board of Editors* (5 year period)—G. R. MacCarthy and E. C. Pliske.

The *Recording Secretary-Treasurer*, J. W. Huddle, the *Permanent Secretary*, E. T. Browne, and the *Editor in Chief*, W. C. Coker, continue in office.

MAN AND MINERALS*

By Jasper L. Stuckey

T. A. Rickard, one of the great mining engineers of the present century, quotes a distinguished Master of Trinity College, Cambridge, as saying: "If you want to arrive at intelligible issues—not to say conclusions—in any discussion, begin by settling the meaning of the terms you are about to use."

In the present discussion the words man, mineral and civilization will be used frequently. By man is meant the whole line of hominid or man-like beings from *Pithecanthropus erectus* to present day man, people like ourselves. Mineral is commonly defined today as an inorganic homogeneous substance of definite composition and physical properties found in nature. The term "mineral resources" is used to denote all products of value taken from the earth's crust—such as minerals, metals, coal and rock products. As used here the word mineral includes all materials from the earth's crust that man has found useful. Civilization, as we understand it, is a thing of men and materials which are joined in producing a social order that may express itself in a bridge or or a statue, in a hospital or a temple, in a park or a picture. It is the work of the artisan and the artist joined in creating a better social order.

Man's progress along the road to civilization is marked by a number of milestones to which Archeologists have given such names as the Paleolithic Age, the Neolithic Age, the Bronze Age and the Iron Age. Each of these names indicates the nature of the more important materials used by man in the different stages of his development.

No one culture has prevailed over the whole earth at the same time. One group of people advanced to a new stage while a less fortunately located group remained in an older stage of development. Some groups had learned to use iron while some still used bronze and others stone. The entire western hemisphere, the whole of Australia, the great Pacific area, and parts of Asia and Africa remained in the New Stone Age until

* Presidential address delivered before the North Carolina Academy of Science at Chapel Hill, N. C., April 25, 1941.

about four centuries ago and passed directly into the Iron Age without ever having known bronze. Even today remote and isolated tribes like the New Guinea Papuans are actually living in the Stone Age.

The earliest records of a being with enough intelligence to use even the crudest stones—the man of the Eolithic or Dawn Stone Age—seems to have appeared far back in the Ice Age or Pleistocene epoch if not earlier still in the geological period known as the Pliocene. This means that Eolithic man appeared at least 500,000 if not 1,000,000 years ago. Neanderthal man, the true Paleolithic or Old Stone Age man who first lived in caves, appeared about 50,000 years ago during the coldest of the Ice Ages. The Cro-Magnon man or true *Homo sapiens* appeared in Europe about 25,000 or 30,000 years ago. Neolithic man came into prominence about 10,000 or 15,000 years ago. The beginning of the Age of Bronze and the first knowledge of writing occurred something like 5000 or 6000 years ago. If these estimates are correct, the entire historical portion of man's existence, the only part we know through written records, amounts to less than one per cent of his total existence.

EOLITHIC OR DAWN STONE AGE

The earliest traces of primitive man and his use of minerals are found in late Pliocene and early Pleistocene deposits which were laid down during a mild climate before the advancing ice sheets had chilled the northern hemisphere. During this time man's chief need was for defense against the dangerous wild animals of the time.

The earliest evidence of human handiwork consists of flints so rudely fashioned that they are difficult to distinguish from those broken by frost or other natural processes. These flint implements were made almost exclusively from the cores of pebbles or nodules and much of the crust or original surface of the pebble was left on the completed implement.

EARLY PALEOLITHIC OR OLD STONE AGE

In the early Paleolithic Age, although glaciers were gradually expanding, they had not materially chilled the earth and although fire was probably known there is little to indicate that man made any use of it. The Early Old Stone Age is marked by a considerable improvement in the making and a greater variety in the forms and numbers of flint implements produced. At least seven or eight types have been distinguished, each adapted to some particular purpose or use, though a few were doubtless combination tools. The cores of pebbles and nodules

continued to be used chiefly, although a few flakes were possibly utilized. The shapes of the implements indicate that they were used primarily for cutting, scraping and boring. The "fist ax" became well established and highly developed. It is found in several shapes, the most typical being a heavy, rough, almond-shaped tool which was used for hacking with the edge and striking with the pointed end. This tool, which was chipped over its entire surface as well as along its edges illustrates the improvements in implement making.

UPPER PALEOLITHIC OR OLD STONE AGE

During the Upper Paleolithic Age, in the fourth and last great glacial stage, the warm climate and life forms of Europe died out and were replaced by a cold climate and Arctic fauna and flora. It was during this cold glacial stage that Neanderthal man came into prominence. While he rarely lived in the open, it appears that he lived only in the portions of caves near their mouths, for it is in or near the mouths of caves that remains of his camp fires are found.

Unlike his predecessors, Neanderthal man manufactured his stone implements chiefly from flakes rather than cores. The flake implements combined greater ease of manufacture with much greater effectiveness. They took different forms and were probably designed for chopping, hacking, scraping, drilling, boring, piercing, sawing, and cutting. A type of notched scraper of flint seems to have been developed for dressing down wooden objects such as spear shafts. Spears and clubs were armed with flint points to secure greater power of penetration.

Neanderthal man was probably the first to bury his dead, and there is evidence that he used mineral pigment in connection with burials. Along with his dead, he buried an abundance of finely worked flint implements, shells, and probably food.

Neanderthal man gave way in western Europe to the splendid Cro-Magnon race with a vastly superior culture—a cave dweller, but of a type superior to the lowly Neanderthalers. Cro-Magnon man based his flint working mainly on the utilization of flakes and flake tools, and weapons were longer, narrower, thinner and more delicately formed. He made flint knife blades, points, borers, scrapers and planing tools and used stones for both hammers and anvils. He also invented the shouldered point or barb, a new type of flint with a projection on one side.

Early in his existence Cro-Magnon man invented the engraving tool, a flint with a sharp point used for carving various sorts of figures on cave walls. The remarkable representations of animals which Cro-Magnon

artists incised and painted in mineral pigments on the walls of caves, and modeled in clay on their floors, have attracted attention and admiration all over the world. These uses of clay along with ocher and oxide of manganese as pigments were new advances in the use of minerals. There also developed a high type of carving on bone, ivory and horn. Some of the engravings in Spain indicate that late Paleolithic man knew and used the bow and arrow.

THE MESOLITHIC OR MIDDLE STONE AGE

The Paleolithic Age gradually passed into the Neolithic Age through the transition period commonly referred to as the Mesolithic Age. During this period man made many advances and developments along the road to civilization. He invented the stone ax, his first means of chopping down trees, building huts and constructing canoes. The first crude pottery was made in Mesolithic time, a further expansion of the use of clay which is so important today. He learned to use the soil—another important mineral—and began a very rudimentary agriculture and also learned the art of polishing his stone implements.

THE NEOLITHIC OR NEW STONE AGE

Paleolithic man used flint almost exclusively because it was hard and brittle. Neolithic man made many implements by flaking, but finished some of his tools by grinding. As a result, he used many softer but tougher rocks. The typical products were the pick and ax. The pick was chipped all over and had parallel sides, while the ax was made by flaking on each side. Later the axes were of polished stone and oval in section. When it was discovered that an edge could be given a stone tool by grinding it upon a slab of sandstone, axes were made of a larger size with squared edges. Later still came the polished stone axes with a hole in the middle for a handle and both ends prepared for use as a battle-ax. Along with the development of the stone ax came an array of flint arrowheads, spears, and knives.

Pottery which was crude in early Neolithic times soon developed into a valuable utensil, and man had developed his first important vessel for cooking. He soon found that rocks such as soapstone were resistant to heat and easily shaped. In regions where such rocks are common, various utensils were produced abundantly.

Neolithic man doubtless discovered that flint when freshly extracted from the ground was much more easily chipped than the dried stone found on the surface. The search for fresh moist flint soon led to mining.

The mines at first consisted of trenches, but later shafts were sunk, and from the bottom of the shafts drifts or chambers were developed into the surrounding rock. A number of such prehistoric mines have been discovered in Belgium, France, and England. Soft iron oxide was mined for paint in Missouri, and evidence of mining by pre-historic man was discovered in mica mining in Mitchell County, North Carolina, in 1869. With the development of pottery, clay mining became important, and both open cut and underground methods were used.

The erection in the late Neolithic Age of monoliths and structures composed of hugh stones at Stonehenge, England, in Peru and Yucatan, mark the extensive use prehistoric man was able to make of stone before he had metal for tools.

When the western hemisphere was discovered, the people then here were still living in the New Stone Age, although Europe and western Asia had been living in the Iron Age for more than 2000 years A complete survey of the various tribes and cultures of North and South America, which space here does not permit, would reveal practically every step in Neolithic man's use of minerals. Here have been found stone implements from those chipped to those completely polished; pottery varied from the crudest mud vessel to highly decorated and finished forms; and buildings varied from the earth covered hut to the magnificent temples of stone in Yucatan and Peru.

THE AGE OF METALS

The Neolithic Age passed gradually into the Bronze Age through the Chalcolithic Period or the Copper and Stone Age. In fact, long before the close of the Neolithic Age prehistoric man had learned to collect and use for ornamental purposes such metals as gold, silver, copper, and iron. Native gold and silver, while widespread in nature, proved too soft and too scarce to serve as materials for every day use. Native copper, while much less widespread, is more abundant in some localities and became important because it could be hammered, without heating, into ornaments and implements. Native iron is exceedingly scarce as a mineral, but numerous specimens of meteoric origin were found and used.

Gold, silver, copper, and iron ornaments have been found in the Indian mounds of the Mississippi Valley. Gold has been found in Neolithic remains in Ireland and France. Silver, which analyses show to have been native, has been found in the prehistoric remains around the Mediterranean Sea. Iron finger-rings have been found in graves of the Mycenaean Period, and iron beads strung alternately with gold beads have been found in the predynastic graves of Egypt.

When North America was discovered copper was in general use by the Indians as ornaments of many types. Most of this copper evidently came from the nuggets that had been carried south by the glaciers from the Lake Superior region. Some mining was attempted however, for in an old trench in the Minnesota lode the early prospectors found a mass of copper weighing six tons that the aborigines evidently had tried to remove. They had raised it five feet by aid of timbering and then had abondoned it. More than ten carloads of stone hammers and numerous stone wedges were gathered in the community.

The Age of Metals really began when man learned that he could shape them by the aid of fire. In time this process was naturally followed by the discovery of the metallurgical process of extracting metals from their ores. This seems to have occurred 4000 to 3500 B.C. There was a long period, however, between the time man learned that fire aided in shaping copper and the time he discovered the process of extracting metals from their ores. This period is the true Chalcolithic Age. During this period stone and copper implements were used together, and the copper implements whether hammered out cold or cast in simple molds kept the form of their stone predecessors.

THE BRONZE AGE

Most copper ores contain impurities, and as a result the metallic copper produced by primitive man contained impurities which tended to harden it. In time he learned that copper ores from some localities produced harder metal than that from others. Tin is associated with copper in many regions such as Cornwall, Bohemia, and China. In the course of time bronze was naturally discovered. The absence of a bronze culture in North America is naturally due to the general absence of tin. Bronze seems to have become well established as the alloy from which household utensils, farm tools and implements of war were made about 2200 to 2000 B.C. It was well established about that time in western Asia and gradually moved into Egypt and Greece. The brass armor of Goliath of Gath whom David conquered, and the pillars of Solomon's temple were more likely of bronze. The best evidence now indicates that it was from Hissarlik and Bohemia that the knowledge of bronze became dispersed throughout Europe and adjacent regions.

THE IRON AGE

Meteoric Iron is known to have been used by man as ornaments long before the Bronze Age. An iron tool has been reported found in the great pyramid at Khufu dating from about 3100 B.C. Homer tells us

that the victors in early Greek contests were rewarded with pieces of iron. Even objects of gold were inlaid with iron, so highly was it prized at one time. It now appears from the best records available that iron was first fabricated at Gerar, Palestine, about 1350 B.C.

By about 1000 B.C. or the beginning of the period of recorded history, iron had supplanted bronze as the chief metal for the production of tools and implements of war, and the Iron Age had begun. It is generally conceded that the Iron Age began in Crete about 1100 B.C., in Egypt about 800 B.C., in central Europe about 900 B.C., in Denmark and Sweden about 400 B.C., in Norway about 100 A.D., and in Britain between 50 B.C. and 50 A.D. Three thousand years have passed since iron became an important metal, and we are still in the Iron Age unless we call it the Age of Many Metals.

USE OF OTHER MINERALS

One should not assume that copper and tin of the Bronze Age and iron of the Iron Age were the only metals of importance in those ages. Gold and silver were developed along with copper and had become of great importance by the end of the Bronze Age. Rameses III about 1175 B.C. is reported to have made elaborate gifts of gold and silver to the gods. The Egyptians paid to Darius in 517 B.C. annual tribute of 585,900 ounces of gold. The annual revenue of Ptolemy II, derived chiefly from gold mines, was stated to have been $177,600,000. We are told in I Kings that Solomon's temple was entirely overlaid within with pure gold and that Hiram and Solomon sent ships to Ophir and brought 420 talents or about 23 tons of gold to King Solomon. The location of Ophir and the source of such large amounts of gold have never been established. The silver mines of Greece have been famous for centuries and are important today. It was the silver from Larium that made possible the Greek fleet which defeated the Persian navy of Xerxes in 480 B.C.

Lead is frequently associated with silver and must have become known to man as soon as he began the practice of metallurgy. In the earliest mining at Larium the Greeks discarded the lead in obtaining silver, but in later days the ancient slags were smelted for their lead. The oldest lead was found in the ruins of Hissarlik which date about 2500 B.C. According to Aristotle lead was used to load the dice. The Greek soldiers used it in sling-shots in the fifth century B.C. It was used to reinforce the bronze pegs and iron clamps that held the heavy stones in masonry. Sheets of lead were used for writing, according to Pliny. It

was used in large amounts in coffins and commemorative tablets. The chief use in classic times was for water pipes as revealed in the ruins of Pompeii and Herculaneum.

With the discovery and use of metals came the use of many minerals for ornamental and decorative purposes. The Egyptians prized highly the turquoise from the peninsula of Sinai as well as azurite and malachite, the latter as a cosmetic.

During classical times practically every important gem known today was known and used. Common minerals and rocks such as gypsum, marble, limestone, marl, ocher, and sulphur were known and widely used. Marble was burned into quick lime, gypsum into plaster of Paris, and ochers were burned to improve their colors for paints, while glass blowing came into use early in the Christian Era. Puzzulano cement was made and extensively used by the Romans. Many minor metals such as arsenic, antimony, and mercury were known and widely used. Coal was recognized and described as early as the fourth century B.C. although little use was made of it. Asphalt was well known as it is referred to several times by early Greek writers. Petroleum, while known as such, was of no importance.

Civilization reached a high development in the early Iron Age of the Roman Empire, and the use of minerals became increasingly important. But with the fall of Rome in 476 A.D. civilization and learning were decidedly retarded during the Dark Ages. With the revival of learning came a renewed interest in geography which led to the discovery of the western hemisphere, and a new era in the use of minerals was inaugurated. The desire for minerals has left untouched no part of the earth that can be inhabited by man. We are still living in an iron age, but the iron we know is far superior to that of the Romans. It is an iron alloyed with manganese, nickel, chromium, tungsten, and molybdenum and called steel. The production of this steel demands the services of a host of other minerals, such as coal, petroleum, natural gas, and refractories. The present is truly an age of minerals—many minerals.

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THE GENUS DREPANAPHIS DEL GUERCIO EAST OF THE ROCKY MOUNTAINS[1]

By Clyde F. Smith

Nine Text Figures

Species of aphids belonging to the genus *Drepanaphis* (Aphidae: Homoptera) have been very abundant on various species of maple on the campus of the North Carolina State College during the springs of 1940 and 1941. As many as 43 aphids per leaf have been recorded at times and several of the leaves have turned yellow and dropped off. The lower leaves also became coated with "honey-dew" which detracted from the appearance of the tree. The "honey-dew" dropped by the aphids also proved to be a nuisance to people who wished to enjoy the shade under the maple trees.

Genus *Drepanaphis* Del Guercio

Drepanaphis Del Guercio, Rivista di Patologia Vegetale, N. S., **4** (4): 49–50, September 15, 1909.

Phymatosiphum Davis, Annals Ent. Soc. Amer. **2**: 196, September 29 (?), 1909.

Type: Siphonophora acerifoliae Thomas (monobasic).

Siphonophora acerifoliae Thomas was used as the type species for *Drepanaphis* and *Phymatosiphum*. The publication of *Drepanaphis* bears the date September 15, 1919. We do not know the exact date of publication of the Annals for September 1919 but Doctor C. H. Kennedy informed me that this particular number of the Annals was received at the Ohio State University Library, September 29, 1909. Doctor Kennedy also stated, "We have no other records. The library dates cannot possibly be too early. They might be one or two days too late but it is hardly probable that they are late as in those days Annals published only 500 copies or less, all of which would probably have been wrapped and taken to the Post Office on the same day."

[1] Research Contribution No. 13, published with the aid of the State College Research Fund, Department of Zoology, North Carolina State College of Agriculture and Engineering of the University of North Carolina.

The writer wishes to express his appreciation to Doctor G. F. Knowlton, Doctor F. W. Miller, Mr. P. W. Mason, Doctor F. M. Wadley and Doctor A. N. Tissot for the loan of material or for their opinions concerning certain species of the genus *Drepanaphis*.

Characters.—Frontal tubercles distinct. Antennae bearing minute hairs. Secondary sensoria oval to practically round, ciliated. Primary sensoria ciliated. Fore wings with the media twice branched, hind wings with both media and cubitus present. Conspicuous dorsal tubercles present on the abdomen of the viviparae. Cornicles swollen for proximal two-thirds, usually more than twice as long as broad. Cauda knobbed. Anal plate indented in viviparae. Oviparous female with a distinct elongated ovipositor. Forms living more or less solitary upon the foliage of trees.

There is a great deal of variation in the size and length of the tubercles* between species and even within the same species but the writer has found that the ratio of the lengths of the tubercles to each other seems to remain fairly constant in any given species.

It is interesting to note that the writer has found 5 species of *Drepanaphis* on the same sugar maple tree at the same time. From this observation it can be reasoned that some undescribed species of *Drepanaphis* are being overlooked.† In the case of the writer it was not until he started to separate the material in the field on general appearances and color that he was able to fit the various species into their proper niche.

Drepanaphis Del Guercio

Key to alate vivipara

1. Only the tips of the wing veins and base of radius marked with fuscous 4
   Wing veins, especially radius and medius, broadly bordered with fuscous for their entire length (this is seen most clearly through the low power of the microscope) 2

2(1). Abdominal tubercles I and II absent or inconspicuous, III large and conspicuous (Fig. 7-B) *keshenae* Granovsky
   Abdominal tubercles I and II conspicuous, longer than width at base 3

3(2). Abdominal tubercle I long and finger-like, practically as long as III and distinctly longer than II; fore femora dusky .. *acerifoliae* Thomas

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* Tubercles in this paper will refer to the dorsal abdominal tubercles on abdominal segments I to IV.

† The writer believes there are some undescribed species of *Drepanaphis* west of the Rocky Mountains, as he has considerable material from Utah and Idaho which is quite different from any material discussed in the present paper. However, he prefers to leave the western material undescribed until someone has an opportunity to study the living material as well as the mounted material.

Abdominal tubercle I never as long as III and usually subequal to II; fore femora pale *parvus* new species

4(1). Tubercle I conspicuous; dorsum of abdomen bearing 3 or more pairs of dorsal tubercles which are conspicuous and usually distinctly longer than width at base 7

Tubercle I inconspicuous; dorsum of abdomen usually bearing only 1 pair of dorsal tubercles which is conspicuous and distinctly longer than width at base (occasionally 2 additional small pairs may be present) (Figs. 6-C, 7-B, 8-C, 9-B) 5

5(4). Many of the dorsal abdominal hairs surrounded by distinct dusky spots; distal one-third of cornicle dark, concolorous with tubercle III 6

Dorsal abdominal hairs not surrounded by distinct, dusky spots; distal one-third or more of cornicle pale, distinctly lighter than tubercle III *kanzensis* new species

6(5). Proximal two-thirds of hind femora light, contrasting with the dark distal end; upper edge of front femora dark, rest of front femora and all of middle femora light; antennal III usually with 12 to 15 sensoria On *Acer spicatum* *spicatum* new species

All of hind femora dusky to fuscous, distal and proximal ends not distinctly contrasting; fore femora dark on upper and lower edges, occasionally dark all over; middle femora often dusky, antennal III usually with 10 to 12 sensoria. On *Aesculus* spp *monelli* Davis

7(4). Tubercles I and II approximately the same length; tubercle II distinctly smaller (shorter) than III, large sensorium on antennal VI with 4 accessory sensoria (Fig. 5-E) 8

Tubercles II and III approximately the same length, tubercle I usually distinctly smaller than II; large sensorium on antennal VI with 5 to 7 accessory sensoria (Fig 1-D). *sabrinae* Miller

8(7). Fore femora and basal portion of fore and middle tibiae pale, middle and hind femora and base of hind tibiae may be slightly obfuscated in some specimens 9

All femora and basal portion of all tibiae dusky to fuscous; middle femora often only slightly obfuscated .*carolinensis* new species

9(8). Antennal II slightly lighter than I, tubercle III, or basal portion of cornicle, cornicle not unicolorous, distal end of cornicle distinctly lighter than basal portion. (If antennal II appears practically concolorous with I, than II is not distinctly darker than hind femora and hind femora is dark.) 10

Antennal II dark, concolorous with antennal I, tubercle III, and basal portion of cornicle; cornicle fuscous and unicolorous, distal end nearly as dark as the base; antennal II darker than hind femora, hind femora pale *nigricans* new species

10(9). Hind femora dusky; middle femora occasionally slightly obfuscated; antennal III usually with 14 to 17 sensoria (10 to 20) *rubrum* new species

Hind and middle femora pale; antennal III usually with 10 to 12 sensoria (8 to 14) *parvus* new species

Genotype *Drepanaphis acerifoliae* Thomas

(Figs. 2-A to 2-C.)

Siphonophora acerifoliae Thomas, Bull. Ill. State Lab. of Nat. Hist. I, no. **2**: 4, 1878.

Drepanaphis allegheneyensis Miller, Canadian Ent. **68:** 81, 1936 (new synonymy).

According to Doctor F. W. Miller, there is only one slide (bearing one alate specimen) of *allegheneyensis* left. The rest of the type material was accidentally lost in a flood. Doctor Miller was kind enough to loan the single specimen of *allegheneyensis* to the writer. After studying the specimen of *allegheneyensis*, the writer believes it is a synonym of *acerifoliae*. The specimen is so mounted that the dorsal abdominal tubercles are difficult to see, but the writer was able to discern three distinct pairs which agree in size and shape with the material being considered as *acerifoliae*. The wing veins are lightly bordered with fuscous as in *acerifoliae* (this is most clearly seen with the low power of the microscope). However, the original description of *allegheneyensis* would lead one to believe the wing veins were not bordered with fuscous and that only two pairs of distinct tubercles were present.

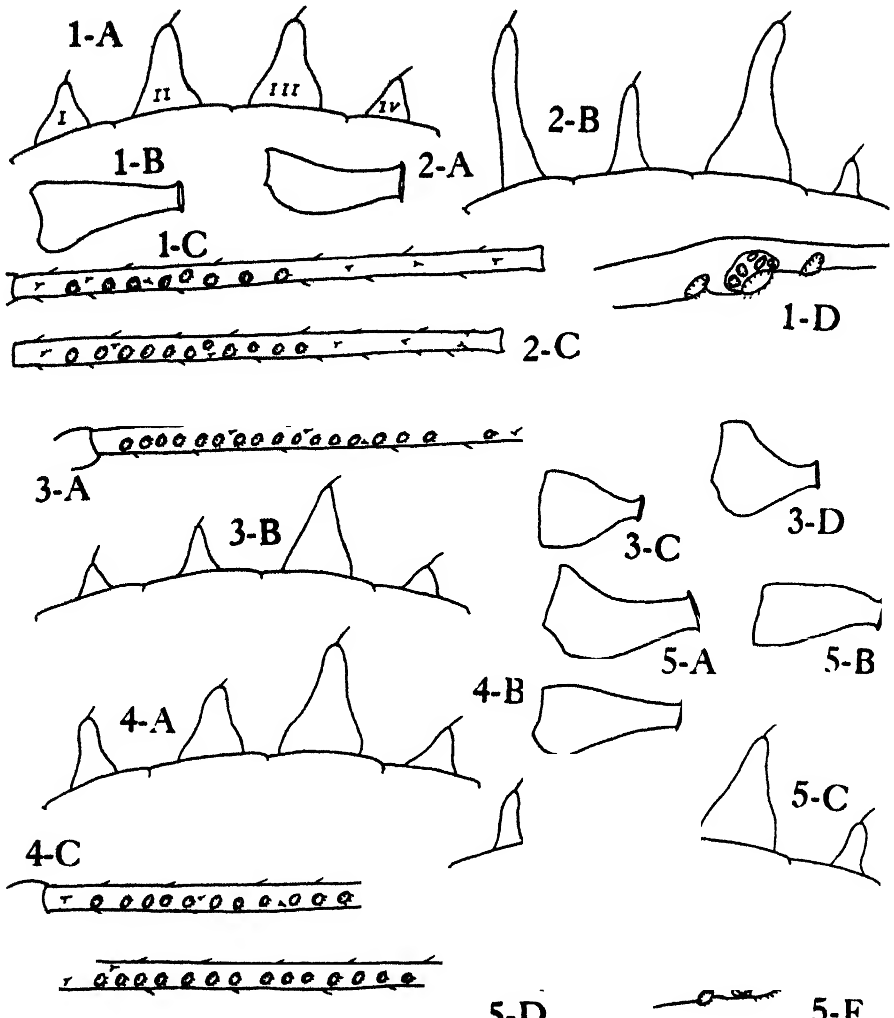
Drepanaphis acerifoliae may be distinguished by its dusky wing veins; and tubercle I being distinctly longer than II, usually being nearly as long as III.

Alate vivipara: General color of living specimens sordid green to light brown with abdomen lighter, especially at tip. Cleared[1] specimens show the following characteristic colorations: dusky brown to fuscous on head and thorax, antennal joints and on antennal VI, all femora, proximal one-tenth of tibiae, tips of tubercles I and II, all of tubercles III and IV, cornicles, large spots on the sides of each abdominal segment cephalad of the cornicles, and small areas around some of the dorsal abdominal hairs; rest of body and appendages pale. Wing veins with dusky borders which nearly fade out when material is treated with potassium hydroxide.

Measurements: Body 1.95 to 2.3;[2] width through eyes .50 to .52; antennal III, .88 to 1.01; IV, .50 to .76; V, .51 to .71; VI, .12 to .14 plus

[1] "Cleared specimens" refers to material that has been treated for a short time with a dilute solution of potassium hydroxide, washed, dehydrated, and mounted in Euparal on glass slides.

[2] All measurements are given in millimeters.



TEXT FIGURES 1-5

1-A to 1-D.—*Drepanaphis sabrinae;* 1-A lateral view of dorsal abdominal tubercles I to IV; 1-B, cornicle; 1-C, antennal III; 1-D, section of antennal VI showing characteristics of sensoria (enlarged).

2-A to 2-C.—*Drepanaphis acerifoliae;* 2-A, cornicle; 2-B, lateral view of dorsal abdominal tubercles; 2-C, antennal III.

3-A to 3-D.—*Drepanaphis nigricans;* 3-A, antennal III; 3-B, lateral view of dorsal abdominal tubercles; 3-C and 3-D, two views of cornicles.

4-A to 4-C.—*Drepanaphis parvus;* 4-A, lateral view of dorsal abdominal tubercles; 4-B, cornicles; 4-C, antennal III.

5-A to 5-E.—*Drepanaphis carolinensis;* 5-A and 5-B, two views of cornicles; 5-C, lateral view of dorsal abdominal tubercles; 5-D, antennal III; 5-E, section of antennal VI showing characteristics of sensoria (enlarged).

.95 to 1.52; rostral IV plus V, .10 to .12; rostrum attaining second coxae; hind tibiae 1.18 to .125; hind tarsus .12 to .13; tubercle I, .15 to .25; II, .12 to .17; III, .21 to .40; IV, .05 to .09; cornicle .26 to .32.

Antennal III with 7 to 15 sensoria; of 51 antennae 1 had 7, 4 had 8, 6 had 9, 9 had 10, 13 had 11, 2 had 12, 9 had 13, 3 had 14, and 4 had 15 sensoria on antennal III. Tubercles I and III are the largest, III usually slightly longer than I and joined at the base; II distinctly shorter than I; IV often nearly as long as II.

Types: In Illinois Natural History Survey Collection, Urbana, Illinois.

Collections: On *Acer saccharinum*, Columbus, Ohio, May, June, & July, 1937 (alate), and October 10, 1937 (ovipara and males); Raleigh, N. C., April, May, and June, 1940; Reidsville, N. C., May 16, 1941.

On *Acer rubrum*, Roaring Gap, N. C., June 6, 1941; Raleigh, N. C., April and May, 1941; Hardeeville, N. C., May 1, 1941; Chapel Hill, N. C., April 26, 1941; Roxboro, N. C., May 16, 1941; Greensboro, N. C., May 28, 1940; Chatham, Virginia, June 12, 1940.

On *Acer platanoides*, Reidsville, N. C., May 16, 1941.

Drepanaphis carolinensis new species

(Figs. 5-A to 5-E)

This species may be distinguished by its pale wing veins; tubercles I and II being about equal in length and smaller than III; femora and base of all tibiae being dark; and only 4 accessory sensoria around the large sensorium on antennal VI.

Drepanaphis carolinensis differs from *acerifoliae* in wing veins not being dusky; tubercle I being distinctly shorter than III and sub-equal to II; and base of tibiae being dark.

Alate vivipara: General color of living specimens greyish brown, appearing somewhat powdery. Cleared specimens show the following characteristic colorations; dark brown to fuscous on antennal I and II, antennal joints and area around sensoria on antennal VI, fore and hind femora, dorsal surface of middle femora (femora may appear mottled), proximal one-sixth of all tibiae, all of cornicles; all of the dorsal tubercles; large spots on the sides of each abdominal segment cephalad of cornicles and small areas around some of the dorsal abdominal hairs. The remaining areas of body and appendages light. Wing veins without dusky borders except base of radius and tips of veins which are dusky.

Measurements: Body 1.6 to 2; width through eyes .53 to 57; antennal

III, .85 to .92; IV, .49 to .52; V, .44 to .51; VI, .13 to .14 plus .76 to .96; rostral IV plus V, .1; hind tibiae 1.03 to 1.12; hind tarsi .15 to .16; dorsal tubercle I, .09 to .13; II, .08 to .11; III, .15 to .20; IV, .06 to .08; V, merely a dark spot which is slightly raised in the center and bears a long hair like the one found at the tip of the other dorsal tubercles; cornicles .20 to .26.

Antennal III with 10 to 18 sensoria, of 79 antennae 3 had 10, 4 had 11, 11 had 12, 17 had 13, 19 had 14, 17 had 15, 3 had 16, 4 had 17 and 1 had 18 sensoria on antennal III; antennal VI with 4 accessory sensoria around the middle sensorium.

Tubercles I and II are approximately equal in length, usually about one-half as long as III and only slightly longer than IV, III is the only one joined at the base.

Types: Holotype in the United States National Museum; paracotypes and paratypes in the writer's collection.

Type locality: North Carolina State College Campus, Raleigh, N. C.

Collections: During the spring of 1940 and again in 1941 this species was very abundant on the southern sugar maples on the N. C. State College Campus, as many as 43 alate specimens being counted on a single leaf.

On *Acer saccharum* var. *floridanum*, Raleigh, N. C., April 28, 1940, holotype slide (6 specimens) and 10 paracotype slides (46 specimens); April 30, 1940, 16 paratype slides (68 specimens); April 26, 1940, 10 paratype slides (51 specimens); May 6, 1940, 10 paratype slides (49 specimens); April 26, 1941, 5 paratype slides (28 specimens); May 10, 1941, 6 paratype slides (33 specimens); May 12, 1941, 1 paratype slide (6 specimens). Chapel Hill, N. C., April 26, 1941, 4 paratype slides (24 specimens); May 14, 1941, 3 paratype slides (19 specimens). Greensboro, N. C., May 14, 1941, 3 paratype slides (17 specimens).

Also collected on *Acer* at Amherst, Mass., May 24, 1936 (F. W. Miller).

Drepanaphis kanzensis new species

(Figs. 9-A to 9-D)

This species may be distinguished by its one large pair of dorsal abdominal tubercles; absence of dusky spots around the dorsal abdominal hairs; and absence of dusky borders along the wing veins.

Drepanaphis kanzensis differs from *monelli* and *spicatum* in lacking the distinct dark areas around the dorsal abdominal hairs; in having relatively smaller and shorter cornicles; in having the base and tip of the cornicles light, distinctly lighter than tubercle III.

Alate vivipara: General color of living specimens not known to the writer. Cleared specimens show the following characteristic colorations: dusky on the head, thorax, antennal I and II, joints of antennae, area around sensoria on antennal VI, tubercles (or spots usually occupied by tubercles) II, III, and IV, middle portion of cornicles and large area on side of abdomen on segment cephalad of cornicles. Hind femora may be lightly mottled. Rest of body and appendages pale. Wings hyaline, veins without dusky borders except base of radius.

Measurements: Body 1.15 to 1.65; width through eyes .46 to .54; antennal III, .8 to .9; IV, .54 to .78; V, .55 to .64; VI, .10 to .13 plus (?). (Unguis broken on all specimens but unbroken part was .90 on one specimen); rostrum attaining second coxae, rostral IV plus V, .08 to .10; hind tibiae 1.00 to 1.2; hind tarsi .11 to .12; tubercle I usually absent or inconspicuous; II usually absent but may be present, .02 to .05; III always large and conspicuous, .18 to .22; IV usually inconspicuous.

Antennal III with 10 to 16 sensoria, of 33 antennae 1 had 10, 7 had 11, 12 had 12, 9 had 13, 3 had 15 and 2 had 16 sensoria on antennal III; antennal VI with 4 accessory sensoria around the middle sensorium. Tubercle III large and conspicuous, joined at the base; I usually absent or inconspicuous; II may be present but is usually small and inconspicuous; IV occasionally present but never very conspicuous.

Types: Holotype slide in the United States National Museum collection; paracotypes in the U. S. N. M. and the writer's collection.

Type locality: Ft. Scott, Kansas.

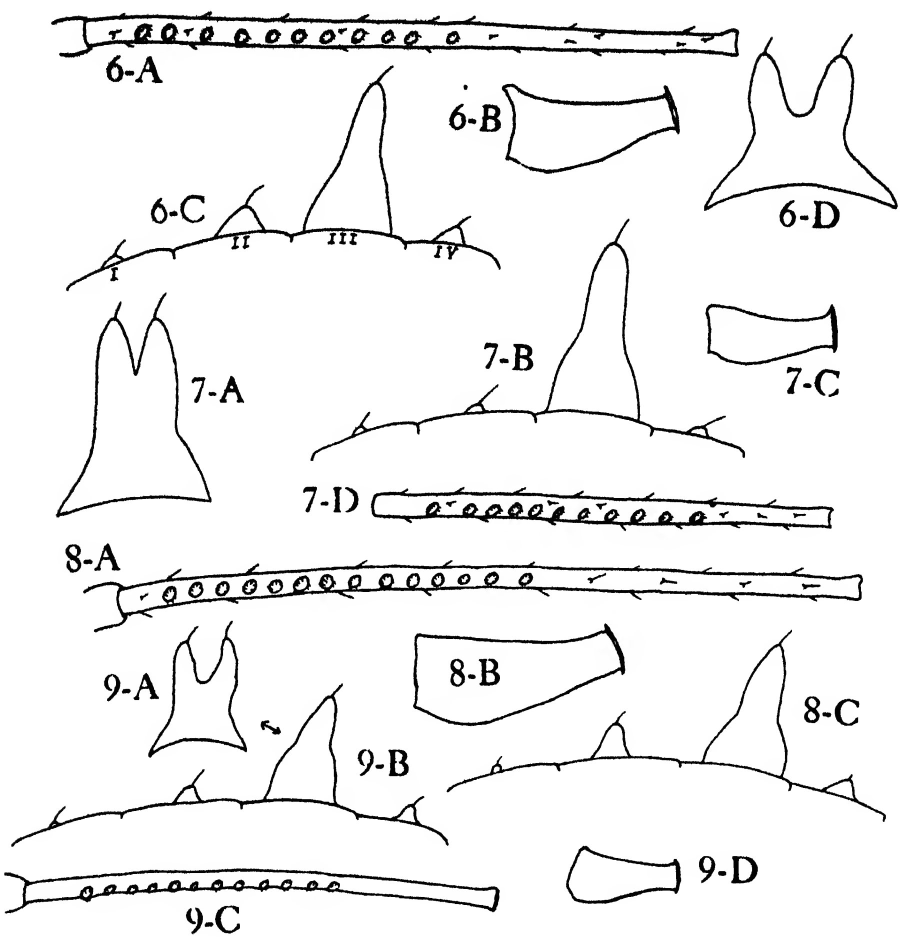
Collections: On Sugar Maple (*Acer saccharum*), Ft. Scott, Kansas, June 17, 1940, holotype slide (5 specimens) and 7 paracotype slides (31 specimens). The above material was submitted to the Bureau of Entomology and Plant Quarantine, U. S. D. A., Washington, D. C., by Dr. F. M. Wadley, who received the material from Dr. H. B. Hungerford. The material was subsequently referred to the writer by Mr. P. W. Mason of the Bureau of Entomology and Plant Quarantine.

Drepanaphis keshenae Granovsky

(Figs. 7-A to 7-D)

Drepanaphis keshenae Granovsky, *in* Hottes and Frison: The Plant Lice, or Aphidae of Illinois. Illinois Natural Hist. Surv. Bull. XIX, article III, p. 248, 1931.

This species may be distinguished by its white waxy covering, single large, conspicuous pair of tubercles and dusky wing veins.



TEXT FIGURES 6–9

6-A to 6-D.—*Drepanaphis monelli;* 6-A, antennal III, 6-B, cornicle, 6-C, lateral view of dorsal abdominal tubercles; 6-D, caudal view of dorsal abdominal tubercle III.

7-A to 7-D.—*Drepanaphis keshenae;* 7-A, caudal view of dorsal abdominal tubercle III; 7-B, lateral view of dorsal abdominal tubercles; 7-C, cornicle; 7-D, antennal III.

8-A to 8-C.—*Drepanaphis spicatum;* 8-A, antennal III; 8-B, cornicle; 8-C, lateral view of dorsal abdominal tubercles.

9-A to 9-D.—*Drepanaphis kanzensis;* 9-A, caudal view of dorsal abdominal tubercle III; 9-B, lateral view of dorsal abdominal tubercles; 9-C, antennal III; 9-D, cornicle.

Color: Living material appears whitish and powdery due to the waxy flocculent material on the body. Cleared specimens show the following

characteristic colorations: dusky to fuscous on antennal I, joints of antennae, more or less of antennae beyond IV, head, thorax, all coxae, fore femora, base of fore tibiae, borders of wing veins, tubercle III, all but base of cornicles, large spots on sides of each segment cephalad of cornicles, and small areas around some of the dorsal abdominal hairs; fore and hind femora and base of tibiae occasionally slightly obfuscated; remainder of body and appendages pale.

Measurements: Body 2.02–2.50; width through eyes .50 to .52; antennal III, .82 to .95; IV, .52 to .62; V, .52 to .56; VI, .12 to .13 plus .75 to 1.24; rostrum nearly attaining second coxae; rostral IV plus V, .10 to .11; hind tibiae 1.1 to 1.2; hind tarsi .12; cornicles .20 to .26; tubercle III, .2 to .3.

Antennal III with 10 to 16 sensoria, of 24 antennae 5 had 10, 3 had 11, 6 had 12, 6 had 13, 1 had 14, 1 had 15 and 2 had 16 sensoria on antennal III. Tubercle III usually the only one present, joined at the base for proximal one-half to two-thirds of its length, tubercle II may be present and quite conspicuous occasionally.

Types: Cotypes in the collections of the U. S. National Museum, Illinois State Natural History Survey (slide nos. 7616–7617), and in the private collection of A. A. Granovsky.

Collections: This species was relatively scarce and solitary, even more so than is usual for species of *Drepanaphis.* Collected on *Acer saccharum* var. *floridanum*, Raleigh, N. C., April and May, 1940; Hocking Co., Ohio, May 15, 1937; High Springs, Florida, May 1, 1940 (A. N. Tissot).

Drepanaphis monelli Davis

(Fig. 6-A to 6-D)

Phymatosiphum monelli Davis, Annals Ent. Soc. Amer. **2** (3): 197, 1909.

This species may be distinguished by its one large pair of dorsal abdominal tubercles; dusky spots around the dorsal abdominal hairs; and by the absence of dusky borders along the wing veins.

Alate vivipara: General color of living specimens dark, somewhat powdery, tip of abdomen lighter; dark band on dorsum of abdomen between cornicles. Cleared specimens show the following characteristic colorations: dusky brown to fuscous on head and thorax, antennal I, joints of antennae, area around sensoria on antennal VI, edges of fore femora, all of hind femora, very basal portion of tibiae, tubercle III, all

of cornicles, large spots on the sides of each abdominal segment cephalad of the cornicles, and small area around most of the dorsal abdominal hairs; middle femora may be slightly dusky; rest of body and appendages pale. Wings hyaline, veins without dusky borders except at very tips, and base of radius.

Measurements: Body 1.92 to 2.15; width through eyes .54 to .60; antennal III, .98 to 1.18; IV, .74 to .86; V, .70 to .80; VI, .12 to .15 plus 1.65 to 1.75; rostrum attaining second coxae, rostral IV plus V; .10 to .11; hind tibiae 1.27 to 1.38; hind tarsi .12 to .13; III, .16 to .36.

Antennal III with 7 to 13 sensoria, of 35 antennae 1 had 7, 1 had 8, 3 had 9, 6 had 10, 15 had 11, 6 had 12, and 3 had 13 sensoria on antennal III; antennal VI with 4 or 5 accessory sensoria around the middle sensorium. Tubercle III large and conspicuous, joined at the base; I usually absent or inconspicuous; II inconspicuous but may be present and quite conspicuous on an occasional specimen; IV, often present and larger than II, when II is small.

Types: In Illinois Natural History Survey Collection, Urbana, Illinois, and United States National Museum, Washington, D. C.

Collections: Redescribed from the "type" slide in the U. S. N. M. labeled St. Louis, Mo., on Buckeye, June 13, 1906 (Monell), another slide in the U. S. N. M. labeled Buckeye, May 15, 1908, St. Louis, Mo.; 26 specimens collected on Buckeye (*Aesculus pavia*), Gainesville, Florida, May 3, 1941 (Tissot and Smith), and High Springs, Florida, April 12, 1940 (Tissot); and 15 specimens collected on *Aesculus* sp. on Grandfather Mt., N. C., July 3, 1941 (Smith).

Drepanaphis nigricans new species

(Figs. 3-A to 3-D)

This species differs from *monelli* in tubercles I, II, and IV usually being more conspicuous; cornicles being relatively shorter and wider at base; and in averaging more sensoria on antennal III. From *parvus* it differs in having antennal II and all of cornicles dark and by averaging more sensoria on antennal III.

Color: Living material appears very dark, nearly black, flecked with white. Cleared specimens show the following characteristic colorations: fuscous on antennal I and II, joints of antennae, area around sensoria on antennal VI, head, thorax, coxae, cornicles (distal tip may be lighter), dorsal tubercles, large spots on the sides of each abdominal segment cephalad of the cornicles, and small areas around some of the dorsal

abdominal hairs; hind femora may be slightly dusky; rest of body and appendages pale.

Measurements: Body 1.85 to 2.15; width through eyes .47 to .55; antennal III, .91 to 1.10; IV, .65 to .95; V, .65 to .92; VI, .12 to .13 plus 1.5 to 1.8; rostrum nearly attaining the second coxae, rostral IV plus V, .10 to .11; hind tibiae 1.15 to 1.4; hind tarsi .11 to .14; cornicles .16 to .24; tubercle I, .01 to .07; II, .06 to .08; III, .20 to .28; IV, .04 to .09.

Antennal III with 15 to 21 sensoria, of 20 antennae 3 had 15, 3 had 16, 7 had 17, 5 had 18, 1 had 20 and 1 had 21 sensoria on antennal III. Tubercle III the largest; I, II, and IV much smaller and usually all about the same size, but I may be smaller in some cases.

Types: Holotype in the United States National Museum; paracotypes and paratypes in the writer's collection.

Type locality: Along Parkway Drive in North Carolina.

Collections: On *Acer rubrum*, 10 miles south of Busick, N. C., July 2, 1941, holotype slide (5 specimens) and 11 paracotype slides (62 specimens); Blowing Rock, N. C., June 12, 1940, 3 paratype slides (9 specimens); Sparta, N. C., June 6, 1941 (2 specimens, not paratypes).

Drepanaphis parvus new species

(Figs. 4-A to 4-C)

This species may be distinguished by its wing veins which are slightly obfuscated; tubercles I and II being about equal and distinctly shorter than III; femora and all of tibiae being pale.

Drepanaphis parvus differs from *sabrinae* Miller in unguis being distinctly longer than hind tibiae, and in the relative lengths of the tubercles. From *carolinensis* it differs in having the femora and base of tibiae lighter colored; in averaging fewer sensoria on antennal III; and in having the base of the cornicle relatively wider.

Alate vivipara: General body color dark brownish, flecked with a whitish secretion, legs pale. Cleared specimens show the following characteristic colorations; dark brown to fuscous on antennal I and II, joints of antennae and area around sensoria on antennal VI, and dorsal abdominal tubercles; large spots on the sides of each abdominal segment cephalad of the cornicles and small areas around some of the dorsal abdominal hairs; pale brown on hind femora and basal half of cornicles; remaining areas of body and appendages pale. Wing veins slightly obfuscated.

Measurements: Body 2.3 to 2.6; width through eyes .55 to .61;

antennal III, .95 to 1.27; IV, .68 to .90; V, .65 to .85; VI, .12 to .15 plus 1.48 to 1.60; rostral IV plus V, .10 to .12; rostrum attaining second pair of coxae; hind tibiae 1.23 to 1.46; hind tarsi .14 to .15; cornicles .23 to .28; dorsal tubercle I, .10 to .13; II, .10 to .13; III, .20 to .27; IV, .07 to .10; V, .03 to .04.

Antennal III with 8 to 14 sensoria, of 48 antennae 1 had 8, 5 had 9, 6 had 10, 17 had 11, 15 had 12, 3 had 13, and 1 had 14 sensoria on antennal III. Antennal VI has 4 accessory sensoria around the middle sensorium. Abdominal tubercles I, II and IV are about equal in length, III is about twice as long as I or II; V is often quite distinct in this species.

Types: Holotype in the United States National Museum; paracotypes and paratypes in the writer's collection.

Type locality: 10 miles west of Greensboro, N. C.

Collections: On *Acer rubrum*, Greensboro, N. C., May 3, 1940, holotype slide (3 specimens) and 6 paracotype slides (33 specimens), May 28, 1940, 3 paratype slides (8 specimens). Raleigh, N. C., April 28, 1940, 2 paratype slides (2 specimens), April 30, 1940, 1 paratype slide (1 specimen), April 21, 1941, 5 paratype slides (14 specimens), May 12, 1941, 2 paratype slides (9 specimens).

Drepanaphis rubrum new species

Drepanaphis rubrum differs from *carolinensis* in having lighter tibiae, fore and middle femora and cornicles. From *parvus* and *nigricans*, the species which *rubrum* resembles most, *rubrum* can be separated by the characters in the key. *Drepanaphis rubrum* has been taken on the same tree with *nigricans* but in the field, *rubrum* can be separated by its general body color being brownish to slightly rusty colored, flecked with a white wax-like secretion, with the tip of the abdomen light; whereas *nigricans* is black, or fuscous, flecked with a white wax-like secretion.

Alate vivipara: General color of living specimens brownish to nearly fuscous in some individuals; abdomen caudad of cornicles, head and thorax flecked with a white wax-like secretion. Cleared specimens show the following characteristic colorations: dark brown to fuscous on head, thorax, antennal I (II dark but slightly lighter than I), antennal joints and area around sensoria on antennal VI, all coxae, hind femora (hind femora often light), proximal two-thirds of cornicles, dorsal abdominal tubercles, large spots on each segment of the abdomen cephalad of the cornicles, and small areas around some of the dorsal abdominal

hairs. Fore and middle femora and distal one-third of cornicles may occasionally be obfuscated but they are usually pale. The remaining areas of the body and appendages light.

Measurements: Body 1.4 to 1.95; width through eyes .48 to .52; antennal III, .78 to 1.15; IV, .63 to .93; V, .64 to .92; VI, .12 to .14; plus 1.53 to 2.00; rostrum nearly attaining second coxae; rostral IV plus V, .09 to .10; hind tibiae 1.10 to 1.41; hind tarsi .12 to .14; dorsal tubercle I, .09 to .11; II, .05 to .11; III, .12 to .21; IV, .05 to .10; V occasionally indicated; cornicles .19 to .24.

Antennal III with 10 to 20 sensoria, of 55 antennae 1 had 10, 4 had 11, 6 had 12, 2 had 13, 8 had 14, 11 had 15, 7 had 16, 6 had 17, 6 had 18, 2 had 19 and 2 had 20 sensoria on antennal III; antennal VI with 4 accessory sensoria around the middle sensorium.

Tubercles I and II are approximately equal in length, about one-half as long as III and only slightly longer than IV; III distinctly joined at the base.

Types: Holotype in the United States National Museum; paracotypes and paratypes in the writer's collection.

Type locality: On Parkway Drive, near Sparta, N. C.

Collections: On *Acer rubrum*, on Parkway Drive near Sparta, N. C., June 6, 1941, holotype slide (3 specimens) and 3 paracotype slides (16 specimens); 20 miles east of Asheville, N. C., May 24, 1940, 2 paratype slides (6 specimens); Little Switzerland, N. C., July 2, 1941, 1 specimen, paratype; near Busick, N. C., on Parkway Drive, July 2, 1941, 3 paratype slides (7 specimens); Saluda, N. C., May 28, 1940, 1 specimen; Pisgah Forest, N. C., May 29, 1940, 4 paratype slides (14 specimens).

Some of the above slides also contain specimens of *nigricans.*

Drepanaphis sabrinae Miller

(Figs. 1-A to 1-D)

Drepanaphis sabrinae Miller, Canadian Ent. **69**: 111, 1937.

This species may be distinguished by its pale wing veins; large number of accessory sensoria on antennal VI; tubercles II and III being about equal in length and usually longer than I; and cornicles being nearly cylindrical.

Alate vivipara: The color of living material is a rather uniform rusty-orange color on the body. Cleared specimens show the following characteristic colorations: Fuscous on thorax, hind femora and base of hind

tibiae, dorsal tubercles, most of cornicles, large spots on the sides of each abdominal segment cephalad of the cornicles, and small areas around some of the dorsal abdominal hairs; slightly dusky to fuscous on antennae (especially antennal I and II), head, fore and middle legs; rest of body and appendages pale.

Measurements: Body 2.4 to 2.6; width through eyes .55 to .58; antennal III, .96 to 1.1; IV, .53 to .62; V, .50 to .59; VI, .13 to .16 plus .99 to 1.1; rostrum attaining second coxae; rostral IV plus V, .10 to .12; hind tibiae 1.25 to 1.34; hind tarsi .14 to .15; cornicles .27 to .30; dorsal tubercle I, .08 to .11; II, .12 to .22; III, .10 to .18; IV, .02 to .06.

Antennal III with 6 to 13 sensoria on the proximal half; of 25 antennae 2 had 6, 5 had 7, 2 had 8, 6 had 9, 6 had 10, 2 had 11, 1 had 12 and 1 had 13 sensoria on antennal III; antennal VI is peculiar in having 5 to 7 accessory sensoria around the middle sensorium (see figure). Tubercle II is often the longest, III is usually about equal in length to II, IV is the shortest and I is usually between III and IV in length; I, II and III are usually only slightly joined at the base. In the original description of *sabrinae*, it is stated, "Dorsum with large pair of dorsal tubercles on each segment I to IV inclusive, those on III united at the base, largest on segments III and IV." The paratype slide which Doctor F. W. Miller loaned to the writer has 3 specimens and all 3 specimens have the largest tubercles on segments II and III. This is also true on the large series of specimens the writer has compared with the paratype slide and considers to be *sabrinae*. Wings hyaline, veins without dusky borders.

Types: In the collection of F. W. Miller.

Type locality: Amherst, Massachusetts.

Collections: Redescribed from a large series of specimens which were compared with a paratype slide which was loaned to the writer by Dr. F. W. Miller.

Drepanaphis sabrinae was collected on the southern sugar maple (*Acer saccharum* var. *floridanum*) at Raleigh, Chapel Hill, and Hardeeville, N. C., during April and May. It was usually found on the same trees and often on the same leaf with *keshenae*, *carolinensis*, and *parvus*. During 1940 and 1941 *carolinensis* was the most abundant, greatly outnumbering all the other species together. *Drepanaphis parvus* and *sabrinae* were about equal in numbers and *keshenae* was the most scarce.

Dr. A. N. Tissot submitted material of *sabrinae* collected on *Acer saccharum*, Ithaca, N. Y., Sept. 13, 1934 (C. R. Crosby).

Drepanaphis spicatum new species

(Figs. 8-A to 8-C)

This species superficially resembles *monelli* and *keshenae* in the field but usually can be separated on the general appearance of the whitish flocculent material which occurs on the body of all three species. In *keshenae* the whole body appears covered with the whitish material; in *spicatum* the dorsum of the thorax and an area between the cornicles is bare and dark; in *monelli* only the dorsum of the abdomen between the cornicles is bare and dark.

Slide mounted material of *spicatum* differs from *monelli* in averaging more sensoria on antennal III, *spicatum* usually has 12 to 15 whereas *monelli* usually has 10 to 12; in having proximal two-thirds of hind femora light and contrasting with tip of femora, also in having all of middle femora and all but upper edge of front femora light. In *monelli* all the femora, especially the fore and hind, are dusky to fuscous.

Alate vivipara: General color of living material whitish, due to powdery material on body; dorsum of thorax and area between cornicles bare and dark. Cleared specimens show the following characteristic colorations: Fuscous on head and thorax, antennal I and base of II, joints of antennae and area around primary sensoria on VI, upper edge of fore femora, distal end of hind femora (base of femora light and contrasting with tip), proximal end of hind tibiae, tubercle III (also II and IV when present), all of cornicles, large spots on the sides of each abdominal segment cephalad of the cornicles and small areas around most of the dorsal abdominal hairs; rest of body and appendages pale. Wings hyaline, veins without dusky borders except base of radius and tips of veins.

Measurements: Body 1.70 to 2.45; width through eyes .56 to .61; antennal III, 1.13 to 1.38; IV, .85 to 1.02; V, .78 to .96; VI, .13 to .15 plus 1.75 to 1.95; rostrum nearly attaining second coxae, rostral IV plus V, .12 to .13; hind tibiae 1.45 to 1.70; hind tarsi .14 to .15; tubercle III, .17 to .22.

Antennal III with 10 to 16 sensoria, of 38 antennae 2 had 10, 3 had 11, 7 had 12, 10 had 13, 9 had 14, 6 had 15 and 1 had 16 sensoria on antennal III; antennal VI with 4 accessory sensoria around the middle sensorium.

Tubercle III large and conspicuous, joined at the base; I usually absent or inconspicuous; II may be present but small and inconspicuous; IV usually subequal to II.

Types: Holotype in the United States National Museum; paracotypes and paratypes in the writer's collection.

Type locality: Mt. Mitchell, N. C.

Collections: On mountain maple (*Acer spicatum*) on Mt. Mitchell (Camp Alice), July 2, 1941, holotype slide (2 specimens) and 8 paracotype slides (23 specimens); Grandfather Mt., July 3, 1941, 1 paratype slide (3 specimens); near Buck Creek Gap on Parkway Drive in N. C., July 31, 1941, 9 paratype slides (45 specimens).

NORTH CAROLINA STATE COLLEGE,
RALEIGH, N. C.

A NEW TURBELLARIAN (RHABDOCOELE) FROM BEAUFORT, NORTH CAROLINA, TRIGONOSTOMUM PRYTHERCHI,[1] N. SP.

By William A. Kepner, F. F. Ferguson, and Margaret A. Stirewalt

Plate 3 and Three Text Figures

This new rhabdocoele was taken from the mud of the "mullet farm" of Piver's Island, Beaufort, North Carolina, during the summers of 1938, 1939, and 1940.

The expenses, incurred in making the study of this form, were met in part by grants made by the Virginia Academy of Science and by the Research Committee of the University of Virginia.

Trigonostomum prytherchi new species.

Specimens 0.75–0.90 mm. long. Cigar-shaped with the larger end the anterior one. Cilia numerous and of uniform length. Five or more flexible, sensory, cytoplasmic hairs along anterior margin. Pigment none, except for the black pigment of the two eyes. Rhabdites rod-shaped, scattered throughout the epidermis. Two wide paths of adenal rhabdites converge to open near the gonopore. Small proboscis with special, small rhabdites. Pharynx[2] doliiform. Enteron dorsal to all other viscera. No protonephridia. Single genital atrium and gonopore. Two ovaries. Bursa copulatrix armed with a spiral, cuticular appendage. Two long, club-shaped vitellaria. An accessory gland opening into posterior region of genital atrium. Two conspicuous false seminal vesicles. Penis armed with a compound, cuticular stilette. Chromosome-number: X = 4, 2X = 8.

This species is described from many co-types, some of which have been sectioned and some of which have been preserved as total mounts.

[1] This species is named after Dr. H. F. Prytherch, Director of the United States Bureau of Fisheries Laboratory, Beaufort, North Carolina, who has shown us many courtesies, and made helpful suggestions while this and other turbellaria were being studied.

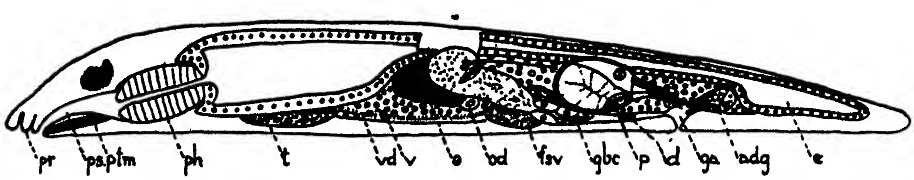
[2] The pharyngeal sheath, in the living specimen, appears to open into the proboscis-sheath. If this were the case, this animal would have to be assigned to Graff's (1911) genus, *Woodsholia lilliei*. It would resemble this species more nearly than any species of *Trigonostomum*.

A total mount has been deposited in the United States National Museum (U. S. N. M. Cat. no. 20593) and others are in the collection of the Miller School of Biology (U. Va. no. 819,827–1, 827–2, 827–3, and 827–4).

This species' most pronounced characteristic is the proximity of the mouths of the pharyngeal sheath and of the proboscis-sheath.

ANATOMY OF THE SPECIMEN

The colorless, cigar-shaped animal moves with its wider end directed anteriorly (Pl. 3, Fig. 1). In cross sections, the body appears circular, there being no flattened region. It is a free-swimming form moving by means of a dense coat of short, uniform cilia. The anterior margin bears five to ten long, sensory, protoplasmic hairs, that have the power to bend ventrally beneath the body (Fig. 1, *sh*). Many short, club-shaped



TEXTFIGURE 1. Reconstructed lateral aspect of specimen. *adg*, accessory gland associated with genital atrium; *e*, enteron; *d*, denticles of stalk of bursa copulatrix; *fsv*, false seminal vesicle; *ga*, genital atrium; *gbc*, glandular region of stalk of bursa copulatrix; *o*, ovary; *od*, mouth of oviduct; *p*, penis; *ph*, pharynx; *pr*, proboscis; *ps*, pharyngeal sheath; *ptm*, protractor muscle of pharynx; *t*, testis; *v*, vitellarium; *vd*, approximate position of vas deferens, organ not observed. × 125.

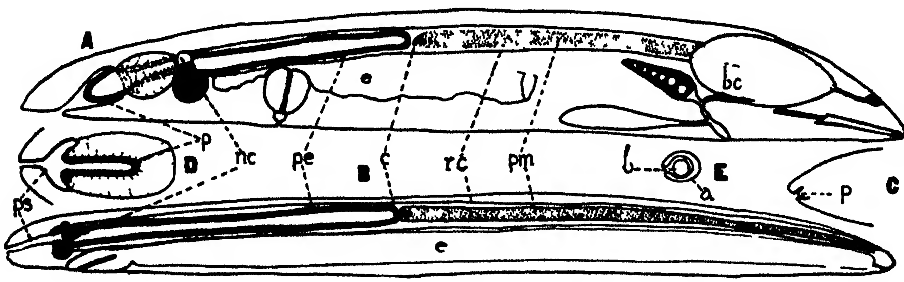
rhabdites are scattered throughout the epidermis. Two strands of conspicuous adenal rhabdites (Fig. 1, *arb*) extend anteriorly as they bend about the posterior ends of the vitellaria to converge to and open in the vicinity of the common gonopore. The epidermis is a low epithelium. Each of the two eyes present two regions: (1) a black pigment-cup (Fig. 1, *pc*), and (2) a highly refractive, lens-like structure that projects beyond the margin of the pigment-cup (Fig. 1, *el*). There are three apertures along the mid-ventral line of the body: (1) the mouth of the proboscis-sheath, (2) the mouth of the pharyngeal sheath, and (3) the common gonopore.

The proboscis, next to that of *Microrhynchus virginianus*, is the smallest one that we have encountered in the Kalyptorhynchia. At times it gives the impression of being but a temporarily introverted region of the ventro-anterior surface of body. Sections, however, reveal

that it is a small, but definite proboscis, provided with a peculiar musculature and armed with rhabdites that are smaller and relatively more numerous than those of the general epidermis.

The central nervous system has not been studied. We have observed two ventro-lateral nerve-tracts leading from the posterior surface of the dorsal ganglia. These two ganglia are connected by a short, stout commissure.

An eye lies upon the anterior, dorsal surface of each ganglion. This eye consists of a pigment-cup (Fig. 1, and 2, *pc*) and a retinula or visual cell. We have not determined the number of cells that form the pig-



TEXTFIGURE 2. A, lateral aspect of *Gyratrix hermaphroditus* modified from Bresslau (1933). B, lateral aspect of a typical nemertean. C, anterior end of *Microrhynchus virginianus*, from Kepner and Ruebush (1935). D, anterior end of *Macrorhynchus goettei*, from Bresslau (1933). E, transverse section through cuticular stilette of penis at level of *st* in figure 1. *a*, outer cuticular tube of penis; *b*, inner cuticular tube of penis; *c*, cuticular appendages of modified bursa copulatrix of A, and of proboscis of B; *e*, enteron, *nc*, neural commissure (the unblacked portion, in A, shows the extent the commissure must be raised to let the proboscis be inverted beneath it); *p*, penis; *pe*, eversible portion of proboscis; *pm*, muscular portion of proboscis; *ps*, proboscis-sheath; *rc*, rhynchocoele.

ment-cup. The retinula presents three regions. (1) The rhabdome having the shape of a low cone with a rounded apex (Fig. 2, *rh*). This region of the retinula fills the lumen of the pigment-cup. (2) Projecting beyond the margin of the pigment-cup, is the somewhat plano-convex ellipsoid (Fig. 2, *e*), which in life appears as a conspicuous, highly refractive body. (3) A nucleated region of the retinula extends beyond this ventrally. This is the myoid (Fig. 2, *my*). This nucleus of the myoid is perhaps the largest somatic nucleus to be found in the specimen.

No other organs of special sense have been observed.

The "body-wall" with its epidermis and two layers of muscles is typical for a rhabdocoele. This "body-wall" encloses a pseudocoele.

The pseudocoele is occupied, for the most part, by the viscera, there being a relatively sparse parenchyma.

The alimentary canal is typical. A relatively sort, doliiform pharynx (Fig. 1, *ph*) lies at the base of an anteriorly directed proboscis-sheath (Fig. 1, and Textfigure 1, *ps*). The enteron (Fig. 1 and Textfigure 1, *e*) is an extensive sac that sends a diverticulum anteriorly along each side of base of the pharynx. The wall of the living enteron bears many more or less refractive bodies of variable size causing it to be opaque and yellow. It lies dorsal to the other viscera. The latter can only be seen in a slightly compressed living specimen and in sectioned specimens.

No water-filtering apparatus is present—neither flame-cells nor protonephridia.

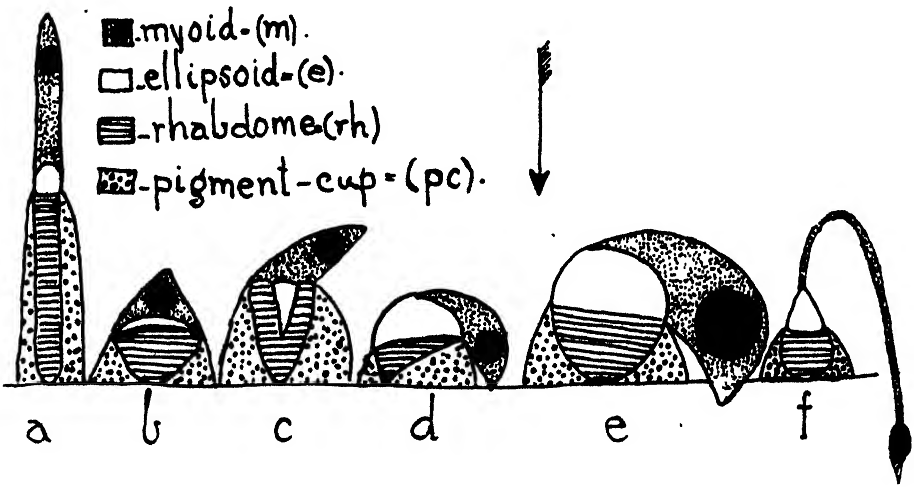
The specimens are hermaphroditic. We have not determined whether they be protogenous or protandrous.

The male reproductive system includes two oval testes (Fig. 1, and Textfigure 1, *t*) which are quite large. Each is connected with the copulatory organ by means of a vas deferens. Each vas deferens expands to form a false seminal vesicle (Fig. 1, and Textfigure 1, *fsv*). Within the oval bulb of the penis are two regions. The anterior, larger, region bears large cells which we consider to be granular cells (Fig. 1, *vgc*) crowded about the vesicula seminalis (Fig. 1, *vs*). The vesicula granulorum (Fig. 1, *vg*) occupies the posterior tip of the oval penis-bulb. Leading from this posterior tip of the penis-bulb, is a compound, cuticular stilette (Fig. 1, *st*). This is composed to an anterior outer funnel, that has had its shorter convex wall folded in upon the longer outer wall (Textfigure 2, E, *a*). The second, cuticular element of the stilette is a longer, very slender, funnel bent at right angles at its anterior end. Its straight, posterior part (Textfigure 2, E, *b*) lies within the folded outer funnel.

The female reproductive system includes a pair of oval ovaries (Fig. 1, and Textfigure 1, *o*) that lie near the middle of the body. We have seen the mouth of each oviduct (Textfigure 1, *od*) but have not been able to trace the oviducts to the genital atrium. Two club-shaped vitellaria (Fig. 1, and Textfigure 1, *v*) lie along the margin of the pseudocoele beneath the enteron. These yolk-glands extend from the level of the posterior end of the pharynx to halfway between the gonopore and the posterior end of the body. We have not been able to locate the vitelloducts.

The most conspicuous accessory structure of the female genital system

is the bursa copulatrix (Fig. 1, *bc*). There are three regions to the bursa copulatrix: (1) a stalk; (2) a glandular duct (Textfigure 1, *gbc*); and (3) an elongated vesicle that may contain many spermatozoa in various conditions of disintegration. The stalk of the bursa copulatrix bears a zone of minute, slender, needle-like denticles (Textfigure 1, *d*) within its wall. Anterior to this armed stalk, the bursa copulatrix continues as a duct that is lined with glandular cells (Textfigure 1, *gbc*). The lumen of this glandular duct communicates anteriorly with the vesicle of the bursa copulatrix. The wall of the vesicle of the bursa copulatrix



TEXTFIGURE 3. Series of retinulae and associated pigment from: *a*, vertebrate; *b*, *Geocentrophora steinböcki*; *c*, *Klattia virginiensis*; *d*, *Macrostoma longistyla*; *e*, *Trigonostomum prytherchi*; and *f*, *Euplanaria* (*Dugesia*) *tigrina*.

is fibrous (Fig. 3, *vbc*). We have found no epithelium associated with this vesicle. The anterior, flexed end of the vesicle bears a remarkable, cuticular structure, or appendage, which the Germans have designated an "Anhang". This appendage (Fig. 1, *ap*) is a chitinous-like, cuticular tube. Its form is that of a spiral, slender, truncated, conical tube with its basal region giving off five to seven secondary tubes (Fig. 3, *sct*). Under high magnification, these secondary tubes are seen to bear at their free ends what appear to be microscopic sieves. These small tubes, in living specimens, seem to lie outside the vesicle of the bursa copulatrix, but our sections reveal that they lie within the lumen of the vesicle. The unbranched end of the appendage lies outside the wall of the vesicle of

the bursa. Its mouth communicates with the pseudocoele. Figure 3 shows a section that involves the passage of the appendage through the wall of the vesicle of the bursa copulatrix. There is thus established a passage-way between the lumen of the bursa's vesicle and the pseudocoele. This passage-way is guarded by sieve-plates that lie at the ends of the receiving tubules of the spiral appendage. Spermatozoa, in various stages of disintegration, are frequently found within the vesicle of the bursa copulatrix. The histological picture suggests that solutions of disintegrated spermatozoa may be screened, by passing through the sieves, and delivered as filtered material to the pseudocoele by the mouth of the smaller free end of the spiral appendage. We are not in a position to defend this suggestion.

The cuticular appendage must have an important function; for it is present in all marine species of the genus, being absent only in a single fresh-water one (Graff, 1913, p. 302). In addition to this, we have found that the cuticular appendage is formed within a single cell. Two cells have been found extending beyond the full-size, functioning, cuticular appendage. Each of these cells has within its cytoplasm a small, cuticular appendage (Fig. 4, *cac*). The tip of this cellular stalk is enclosed by a fibrous "tendon" (Fig. 4, *te*). Thus it is seen that, not only is there present a functioning cuticular appendage, but there are two other young, cuticular appendages held in reserve as are two sets of young, cuticular stilettes held in reserve at the anterior end of the non-eversible region of the proboscis of the Nemertea.

DISCUSSION

The structure of the eye of *T. prytherchi* is of peculiar interest to us. Kepner and Taliaferro (1916) described the eye of *Prorhynchus applanatus*[3] to be composed of but two cells: (1) an accessory or pigment-cell, and (2) a retinula. They further indicated that the visual cell or retinula had a refractive, lens-shaped body lying between the rhabdome and the nuclear bearing cytoplasm. Kepner and Foshee (1917) called attention to the comparison that could be drawn between the retinula of a turbellarian and that of a vertebrate. This comparison was further advanced by Kepner and Lawrence (1918) who found rhabdome, ellipsoid, and myoid in the retinula of *Polycystis goettei*.[4] Steinböck (1927), however,

[3] Later determined to be *Geocentrophora steinböcki* by Porter (1936).

[4] Later determined to be *Klattia virginiensis* by Kepner, Stirewalt, and Ferguson (1939).

takes issue with the above investigators. He has made a study of the European Prorhynchidae and finds no ellipsoid present in their retinulae. Kepner and Stiff (1932) have, since then, found that the retinula of the rhabdocoele, *Macrostoma tuba*,[5] has rhabdome, ellipsoid, and myoid. The conspicuous, highly refractive body *e*, figure 1, as seen in a living specimen, led us to expect to find a single retinula in the eye of this new species. Sectioned specimens satisfy this expectation; for, as shown in figure 2, there is present but a single large retinula with the typical three regions of a visual cell.

Most of the species of *Trigonostomum* have a tendency to have this refractive region of the eye (as seen in living specimens) divided into an anterior and into a posterior half (Graff, 1913, p. 302). It will be interesting to examine the eyes of these other species to determine if there be two retinulae to each eye, and if each of these retinulae has three parts to it.

A comparison between certain anatomical features of *T. prytherchi* and certain anatomical features of Nemertea has shaped itself in our minds.

The proboscis of Kalyptorhynchia varies in size from a very small, insignificant structure, as in *Microrhynchus virginianus* to a powerful, highly specialized organ, as in *Macrorhynchus goettei*. In the latter animal, it may not only be thrown out from the proboscis-sheath, but it may be drawn back within itself as an introvert (Textfigure 2, D).

By way of illustrating the comparison that we have in mind, let us examine certain anatomical features of the kalyptorhynchian, *Gyratrix*. We have in this animal a proboscis and proboscis-sheath at the anterior end (Textfigure 2, A, *p*). A pair of ganglia, connected by a transverse neural commissure, lies between the pharynx and the proboscis. A stalked bursa copulatrix extends dorsally and anteriorly from the posterior end of the *Gyratrix's* body (Textfigure 2, A, *bc*). If this bursa copulatrix were armed with a special, cuticular appendage and two accessory ones, as in *T. prytherchi* and were to become elongated to form an anteriorly directed, muscular strand and carry with it its cuticular appendages (the largest of which becoming a tack-like stilette and the other two accessory, tack-like stilettes), we should have formed the posterior region of a nemertean's proboscis (Textfigure 2, B, *pm*). Next, let the proboscis of *Gyratrix* become more and more introverted to pass-

[5] Later determined to be *Macrostomum bulbostylum* by Ferguson (1940).

beneath and beyond the neural commissure (Textfigure 2, A, *nc*) posteriorly as *pe* in Textfigure 2, A and B. We should then have the anterior eversible part of nemertean's proboscis.

The suggestion is thus raised that the eversible region of the nemertean's proboscis is the homologue of the proboscis of a rhabdocoele; whereas, the muscular, retractor part of the nemertean's proboscis is the homologue of the bursa copulatrix of a rhabdocoele. No homologue has been devised for the rhynchocoele of the nemertean. This may represent a region of the pseudocoele of the rhabdocoele.

If these homologies be valid, they strengthen the evidence that Schepotieff (1912) obtained experimentally. He presented seriological evidence that the Nemertea are more closely related to the Turbellaria than they are to the Annelida.

MILLER SCHOOL OF BIOLOGY,
UNIVERSITY OF VIRGINIA,
CHARLOTTESVILLE, VA.

NORFOLK BRANCH OF WILLIAM AND MARY COLLEGE,
NORFOLK, VA.

FLORA MACDONALD COLLEGE,
RED SPRINGS, N. C.

U. S. BUREAU OF FISHERIES STATION,
BEAUFORT, N. C.

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EXPLANATION OF PLATE 3

Figure 1. Dorsal aspect of a slightly compressed specimen. *ap*, cuticular appendage of bursa copulatrix; *arb*, path of adenal rhabdites; *bc*, vesicle of stalked bursa copulatrix; *e*, enteron; *el*, ellipsoid of eye; *fsv*, false seminal vesicle; *o*, ovary; *pc*, pigment-cup of eye; *ph*, pharynx; *ps*, pharyngeal sheath; *sh*, protoplasmic, sensory hair; *st*, stilette of penis; *t*, testis; *v*, vitellarium; *vg*, vesicula granulorum; *vgc*, granular cells; *vs*, seminal vesicle. × 225.

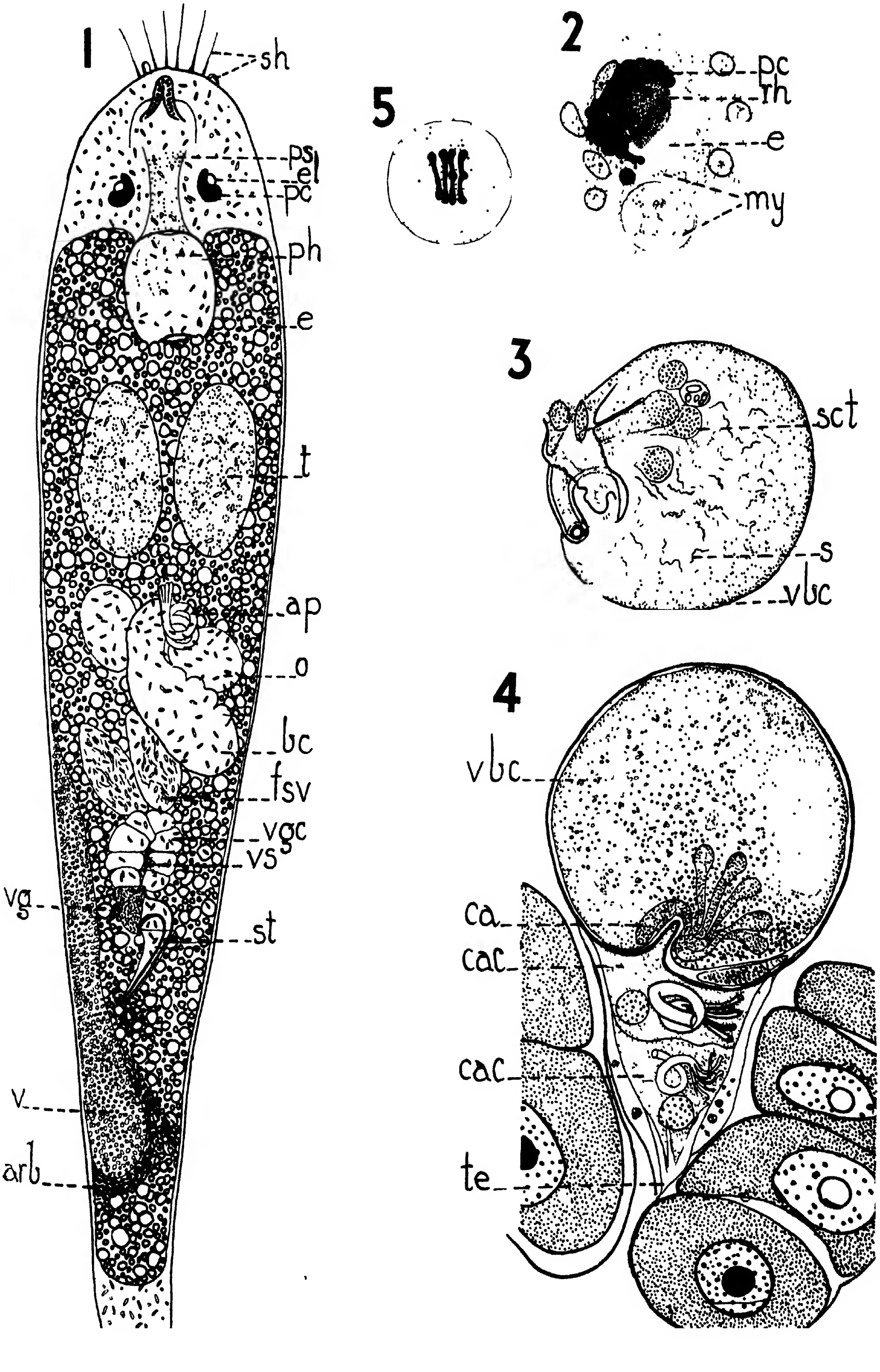
Figure 2. Axial section of an eye. *e*, ellipsoid; *my*, myoid; *pc*, pigment-cup; *rh*, rhabdome. × 1125.

Figure 3. Obliquely transverse section of anterior region of vesicle of bursa copulatrix. *s*, spermatozoon; *sct*, secondary (branch) cuticular tube with sieve across its mouth; *vbc*, fibrous wall of vesicle. × 1125.

Figure 4. Section involving cellular region of tip of vesicle of bursa copulatrix. *ca*, cuticular appendage; *cac*, cells each containing an accessory, cuticular appendage; *te*, tendon-like anchoring strand; *vbc*, vesicle of bursa copulatrix. × 1125.

Figure 5. Meiosis of spermatogenesis. × 1500.

PLATE 3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A NEW TURBELLARIAN (ALLOEOCOELE) FROM BEAUFORT, NORTH CAROLINA, PLAGIOSTOMUM DAHLGRENI N.SP[1]

By William A. Kepner, M. A. Stirewalt, and F. F. Ferguson

Plate 4

This undescribed alloeocoele was taken at low tide from algae about the sea-wall; from the mud of the "mullet farm" of Piver's Island; and from mud in Taylor's Creek, during the summers of 1938, 1939, and 1940. It was found in greatest numbers in the "mullet pond."

The expenses incurred in collecting were in part met by grants made by the Research Committee of the University and by the Research Committee of the Virginia Academy of Science. We are also indebted to Dr. H. F. Prytherch, Director of the United States Bureau of Fisheries Station at Beaufort, for the use of space and equipment in the Station's laboratory.

Plagiostomum dahlgreni new species.

Specimen 0.65–0.90 mm. long. Shape, slender spindle with anterior end blunter than posterior one. Ciliation uniform. Colorless. Pigment none, except for black granules that crowd about the retinulae of each of the two eyes. Rhabdites short, slender, oval structures uniformly distributed throughout the epidermis. Pharynx variabilis. No protonephridia observed. Two ovaries lying by the anterior lateral region of the enteron beneath the two club-shaped vitellaria. Ovaries become confluent with a peculiar parenchymal stroma posteriorly. A simple female genital canal extends from the dorsal posterior limit of this stroma to open dorsally into the genital atrium. The stroma contains indigenous oocytes and exotic (transferred) spermatozoa. Two small testes are associated with the ventral posterior margin of the stroma. Spermatozoa, each ensheathed in jelly-like substance, crowd into a conspicuous vesicula seminalis. No vasa deferentia have been observed. Neither a vesicula granulorum nor granular glands have been observed. A cylindrical penis, with a conspicuous muscular penis-sheath. The penis-sheath armed with seven to nine aciculophores. A single gonopore. Chromosome number: $n = 3$; $2n = 6$.

[1] This species is named for Professor Ulric Dahlgren of Princeton for two reasons: (1) he trained the senior author as an histologist; (2) he made an important observation upon a plagiostomid that has aided the interpretation of some of our data.

This species is described from numerous co-types, many of which have been sectioned and some of which have been preserved as total mounts. A series of sections has been deposited in the United States National Museum (U. S. N. M. cat. no. 20594) and the others are in the collection of the Miller School of Biology (U. Va. no. 825–2, 11, and 18, and 841–1, and 2).

This species' most pronounced diagnostic feature is the penis-sheath with its aciculophores.

ANATOMY OF THE SPECIMEN

The cigar-shaped body moves with the pointed end of the cigar directed posteriorly (Fig. 1). The mid-ventral surface is flattened (Fig. 2 and 3). There is a dense coat of short cilia of uniform length. Small dermal rhabdites (Fig. 3, *rh*) occur throughout the epidermis. The optical pigment-cups' black pigment represents the only pigmentation. There are only two apertures. These lie in the mid-ventral line. The mouth of the shallow pharyngeal sheath (Fig. 2, *phs*) lies near the posterior limit of the anterior 8th of the body. The gonopore (Fig. 1, *gp*) lies near the anterior limit of the posterior 8th of the body.

The neural equipment consists of a simple central nervous system and three organs of special sense. The central nervous system is represented by a pair of conspicuous ganglia that are connected mesially by a short commissure. A pair of tapering ventro-lateral nerves is given off posteriorly from the ganglia. We have not been able to discover dorsal and ventral neural commissures, that are typical of alloeocoeles, in this species.

We have found, however, a ventro-median sensory area that is connected by a nerve tract with the antero-ventral region of the ganglia. We have designated this region the sensory pit (Fig. 2, *sp*). The sensory pit's epithelium is obviously a modified region of the epidermis. Its cells differ from those of the general epidermis in that they are lower, lack cilia, and bear no rhabdites. Some large unicellular glands have their ducts open along the anterior margin of the sensory pit.

Somewhat embedded in the dorsal region of each ganglion is a simple eye. This eye is composed of a pigment-cup that bears a dense mass of brownish-black pigment. Within the lumen of the pigment cup lie three or more rhabdomes of as many retinulae. The retinulae appear to have the structure described for *Macrostomum* by Kepner and Stiff (1932).

Two layers of myocytes lie beneath the epidermis. The elements of the outer layer are arranged transversely while those of the inner layer are disposed longitudinally. The epidermis and muscular layers con-

stitute a simple body-wall that encloses a pseudocoele, throughout which there is distributed a parenchyma.

The parenchyma is differentiated in a striking manner. In the anterior, posterior, and dorsal regions, there are found cells of irregular contour. These cells constitute a parenchyma that is typical for many Turbellaria. A very conspicuous fibrous stroma (Fig. 1 and 3, *st*) extends throughout the ventral mid two-fifths of the pseudocoele. The generalized anterior, posterior, and dorsal regions of the parenchyma are associated with the ganglia, alimentary canal, and yolk-glands; while the stroma, or specialized region, bears the four gonads at its ends.

The alimentary canal is typical. The pharynx (Fig. 1 and 2, *ph*) is of the type variable, being provided with a shallow sheath (Fig. 2, *phs*). A group of large unicellular glands (salivary glands) (Fig. 2, *sg*) open into the lumen of the pharynx at its posterior ventral margin. This pharynx extends dorsally obliquely to open into a sac-shaped enteron (Fig. 2 and 3, *e*) which lies over the parenchymal stroma to near the posterior limit of the pseudocoele. Granular and ciliated columnar cells constitute the epithelial lining of the enteron. This epithelium and a layer of circular and a layer of longitudinal muscles form the enteric or intestinal wall.

The female reproductive system is simpler than that of most Turbellaria. The two ovaries lie one on each side of the enteron near its anterior end. These gonads are fused with the stroma of the parenchyma. Oocytes (Fig. 3, *oc*) are delivered by these gonads into the parenchymal stroma, within which they are surrounded by a gelatinous layer, which appears to be similar to the "nutritive halo" that Hyman (1938, p. 17) found about the "eggs" of *Hydrolimax grisea*. A female gonoduct (Fig. 2, *fc*) leads from the stroma through the mid-dorsal region of the pseudocoele to open into the dorsal region of the genital atrium. Two club-shaped vitellaria (Fig. 1 and 3, *y*), each lying by the side of the enteron, extend from near the base of the pharynx to the anterior end of the female genital canal. A connection of these vitellaria with either the stroma or the female genital canal has not been determined. The presence of naked spermatozoa throughout the parenchymal stroma is a conspicuous feature of *P. dahlgreni*. Sometimes a sperm-cell appears to be entering the cytoplasm of an oocyte (Fig. 2, *s*). These spermatozoa are naked and we infer that they are not derived from the male genital system of the animal in which they are found.

The male genital system is composed of two testes and a copulatory apparatus.

Two testes (Fig. 1 and 2, *t*) are connected with the posterior region

of the parenchymal stroma into which they send cells that represent various phases of spermatogenesis. No vasa deferentia, connecting these gonads with the vesicula seminalis, have been observed. There is no vesicular granulorum. By the time the spermatozoa reach the vesicula seminalis (Fig. 1 and 4, *vs*) each is supplied with a gelatine-like sheath (in fixed and sectioned material). The vesicula seminalis is connected with the highly muscular bulb of the penis (Fig. 4, *m*) within which the anterior end of the ductus ejaculatorius (Fig. 4, *de*) is coiled. This duct extends down the axis of the muscular penis-sheath. In one case, a slide shows the ductus ejaculatorius elongated and thrown into the female canal (Fig. 4, *ede*). The ductus ejaculatorius may, therefore, function or elongate independently of the penis-sheath.

The penis-sheath is the most remarkable feature of this form. It is highly muscular. The outer and inner layers of circular muscles (Fig. 4, *msp*) are very conspicuous. Between the inner circular muscles of the penis-sheath and those of the penis-bulb is a very muscular sphincter (Fig. 4, *sph*). Lying within the parenchyma of the penis-sheath are from seven to nine series of muscular structures each of which, when mature, bears an aciculum or needle-like rod. These structures we have designated aciculophores (Fig. 2, *aph* and 4 *aph*) (needle- or spine-bearers). The aciculophores may work independently of each other. Their mode of operation is remarkable. One of them may be extended beyond the margin of the penis-sheath (Fig. 2, *aph'*). A flexible aciculum (Fig. 2, *a*) may be thrust out and in from the tip of the protruding aciculophore. While the aciculum and aciculophore are thus functioning, the penis-sheath is being rotated in a manner that suggests exploratory movement. Eventually this striking armature is retracted and the penis-sheath withdrawn into the genital atrium. The penis proper with its ductus ejaculatorius, the penis-sheath, and the aciculophores with their acicula may, therefore, move independently of each other.

One specimen (825–13) presents a penis in which the various parts are breaking down. Specimen 825–12 has no trace of a penis though there is a genital atrium of normal size. It, therefore, appears that the male copulatory organ may disappear as the animal grows old.

SPECIAL OBSERVATIONS

The presence of an anterior sensory pit may be found to be present in all plagiostomids. Böhmig (1890, Taf. 13, fig. 10) shows details, in *Plagiostomum girardi*, that resemble the glandular elements of the sensory region found by Hyman (1938) in *Hydrolimax grisea* and by us

in this form. It is to be pointed out that the relative positions of glandular and sensory regions in Hyman's *H. grisea* are the reverse of those in our *P. dahlgreni.*

The absence of a protonephridial system in *P. dahlgreni* raises the interesting suggestion that water-filtering organs are not as well developed in marine alloeocoeles as in fresh water ones. Von Graff (1911) lists and describes twenty-seven species of this genus. All of these species live in salt water except *P. lemani.* He says of these twenty-seven species that "Der Exkretionsapparat ist nur von *P. lemani* genauer bekannt," p. 361. It is further significant that another fresh-water dwelling plagiostomid, *Hydrolimax grisea,* has an extensive excretory system, that Hyman (1938) says "bears only a general resemblance to that found by Hofsten for *Plagiostonum lemani,*" p. 11.

The presence of the extensive parenchymal stroma, into which exotic sperm and indigenous oocytes migrate, must be emphasized. O. Schmidt, 1852, in establishing the genus did not observe this region of parenchyma. Later observers have indicated that it was present since they describe or depict a region into which male and female sex cells migrate. Von Graff (1882, Taf. 18, Fig. 8) shows a region as extensive as our stroma into which oocytes have migrated. He shows "reife Keimzellen" in each side of the pseudocoele extending up into its anterior tip. He also observed what we designate exotic spermatozoa in this parenchymal region but he designates them "Bindegewebskerne" (Taf. 16, Fig. 19 and 20). Böhmig (1890, p. 199) gives a description of the parenchyma of *P. girardi* which resembles that of the parenchymal stroma of *P. dahlgreni.* Hyman has indicated that the parenchyma of *Hydrolimax grisea* resembles that of *P. girardi* as described by Böhmig. It has occurred to us that Böhmig and Hyman may have overlooked less specialized parenchyma lying at the termini of the pseudocoele.

We make the point that this stroma is a special region of the parenchyma into which the ovaries deliver oocytes, and into which exotic spermatozoa find their way. As early as 1878, Jensen depicted an egg within its shell lying within a region of *Plagiostomum koreni* (Jensen's Taf. 5, fig. 3, *m*) that is comparable to the locality of our parenchymal stroma. Zygotes and eggs with shells may be formed, therefore, in this stroma. If eggs with shells are formed within this stroma, even the vitellaria must then deposit their yolk into this stroma.

This stroma may supply a nutrient material to the oocytes, for many of these sex-cells are surrounded by a halo that is similar to the "noncellular halo presumably of nutritive nature" (Hyman, 1938, p. 16) of

Hydrolimax grisea. The oocytes appear, therefore, to be supplied with nutrient material after they enter the stroma.

Two features of the genital system stand in great contrast. The female genital canal is simple; its wall is weakly constructed and it does not stand in direct connection with either oviducts or ovaries. The male copulatory organ on the other hand is complex but, with it all, lacks a vesicula granulorum.

We have found masses of spermatozoa, each clothed in a jelly-like sheath, within the generalized parenchyma. Specimen, 841-1, displays three such masses of gametes lying dorsal to the posterior region of the penis to the right and left of the female genital canal. In addition to this, there is a fourth mass lying within a cleft in the epidermis. This latter small group of spermatozoa protrudes slightly from what appears to be a wound in the epidermis. Specimen, 825-12 (B1, 6L), carries a similar mass of spermatozoa in the pseudocoele at the level of the cephalic ganglia and eyes. These ensheathed spermatozoa resemble those that are found in the lumina of the vesicula seminalis and of the ductus ejaculatorius. The positions of these masses of gametes also suggest that they are exotic spermatozoa. The inference is made, therefore, that these spermatozoa have been thrown into the pseudocoele by the armed penis of another individual. This inference is supported by the observation made by Professor Dahlgren. He observed that the penis of one *Hydrolimax grisea* ruptures the wall of the genital atrium to throw ensheathed spermatozoa into the pseudocoele and not into the poorly developed female genital canal. Our observations suggest that the complex male copulatory organ is not inserted into the genital atrium during copulation but wounds a fellow animal, sending sheathed spermatozoa through the wound into the pseudocoele. One is curious as to why this species should revert to the peculiar method of transferring spermatozoa such as Kepner, Carter, and Hess (1933) have described for *Stenostomum oesophagium*. These transferred (exotic), ensheathed spermatozoa appear to lose their jelly-like sheaths by the time they find their way into the parenchymal stroma.

Our species differs most from other species of plagiostomids in that it has a poorly developed female genital canal and a highly developed, rather complex, male copulatory organ. Despite the relatively complex character of the ensheathed penis, its mode of transferring spermatozoa to another individual is similar to that of a simple rhabdocoele.

Plagiostomum dahlgreni resembles most closely Graff's (1911) *Plagiostomum wilsoni*. It lacks the median eye and the ciliated ring at the base of the cephalic region that Graff found in his specimens at Woods

Hole. It resembles *P. wilsoni* in having an armed penis-sheath. The penis-sheath of Graff's specimen bore papillae which resemble, in a way, the aciculophores of our specimen when partially protruded. The bristles, too, of the Woods Hole form resemble the protruded acicula of our form. But the position and number of the bristles of Graff's species are quite different from the acicula of our species. The many bristles are numerous and stand at and between the bases of the papillae whereas the acicula are borne within the aciculophores—one to each—and are sent out from the tips of the aciculophores. The papillae and bristles of *P. wilsoni*, therefore, are quite different from the aciculophores and acicula of *P. dahlgreni*.

The genus, *Plagiostomum*, is not as clearly set off as it should be. The majority of species is defined as having penis-sheaths. For example, Graff (1913) describes twenty-seven species. Thirteen of these have penis-sheaths; four of them lack them; while neither the presence nor the absence of the penis-sheath is recorded for the remaining ten. O. Schmidt (1852) did not mention a penis-sheath for his *Vortex Girardi*. This appears to have been an oversight, for when Graff (1882) established the species *P. Girardi*, a synonym for Schmidt's *V. Girardi*, he indicated the presence of a well defined but unarmed penis-sheath (Graff, 1882, Taf. 18, fig. 9). The species without penis-sheaths resemble more closely species of *Hydrolimax* than they do species of *Plagiostomum* that have penis-sheaths. It is suggested that only those species which have ensheathed penes should be included in the genus, *Plagiostomum*.

MILLER SCHOOL OF BIOLOGY,
UNIVERSITY OF VIRGINIA,
CHARLOTTESVILLE, VA.

FLORA MACDONALD COLLEGE,
RED SPRINGS, N. C.

NORFOLK BRANCH OF WILLIAM AND MARY COLLEGE,
NORFOLK, VA.

U. S. BUREAU OF FISHERIES STATION,
BEAUFORT, N. C.

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EXPLANATION OF PLATE 4

Fig. 1. Dorsal aspect of a free moving specimen. *e*, enteron, part of which is shown cut away to show ventral organs; *gp*, gonopore; *o*, right ovary, shown fused with the parenchymatous stroma; *p*, penis; *ph*, pharynx; *st*, parenchymal stroma which bears oocytes and alien spermatozoa; *t*, right testis, shown fused with parenchymal stroma; *vs*, vesicula seminalis; and *y*, anterior portion of right vitellarium, with the left one removed. × 120.

Fig. 2. Reconstructed sagittal section. *a*, aciculum; *aph*, *aph'*, aciculophores; *cg*, cephalic ganglia; *e*, enteron; *fc*, female genital canal; *ga*, genital atrium; *ph*, pharynx; *phs*, pharyngeal sheath; *s*, spermatozoon about to enter an oocyte; *sg*, salivary, pharyngeal glands; *sp*, anterior sensory pit; *st*, parenchymal stroma; *t*, right testis; and *v*, left vitellarium. × 150.

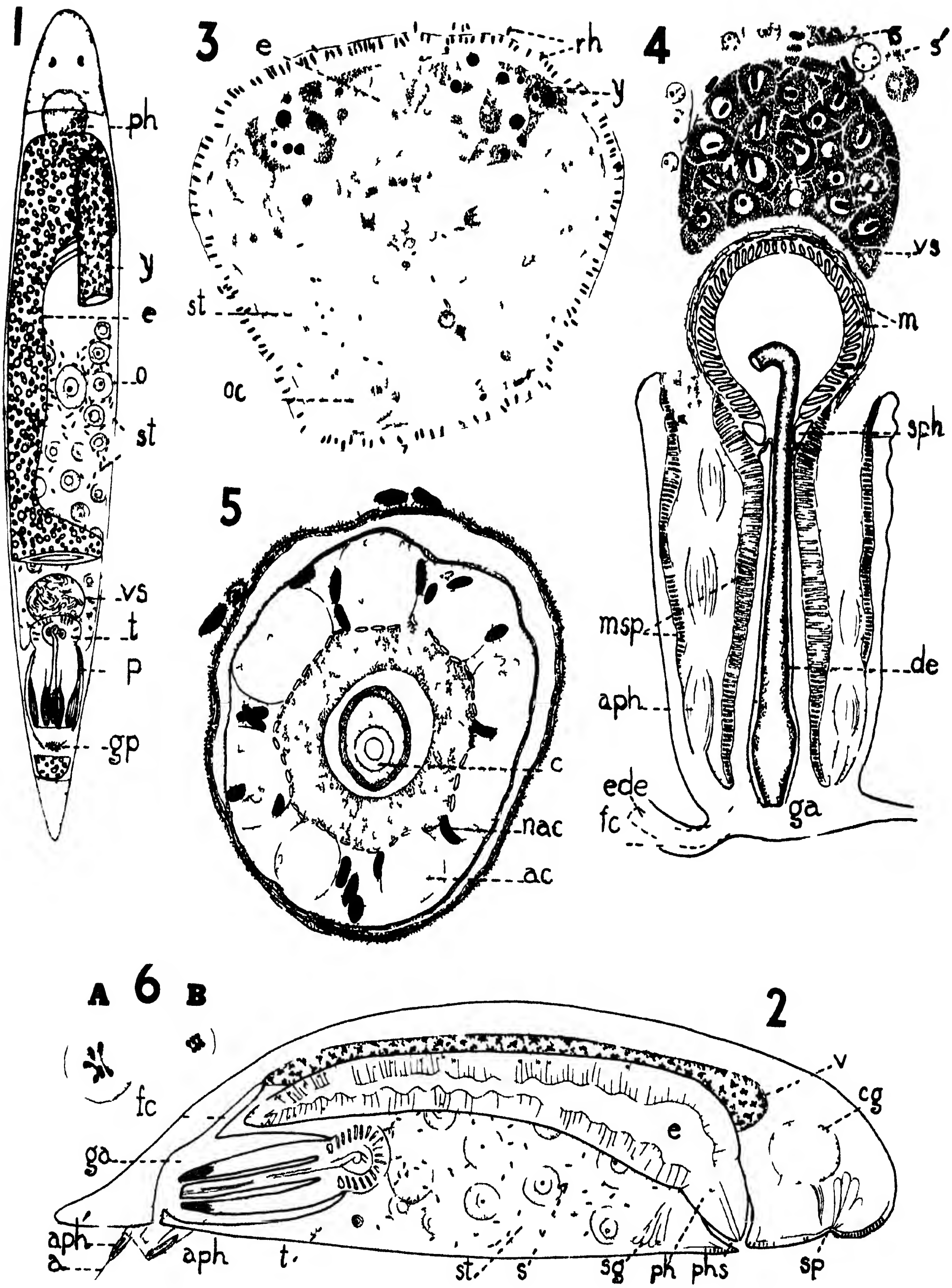
Fig. 3. Transverse section. *e*, enteron; *oc*, oocyte; *rh*, rhabdites; *st*, parenchymal stroma; and *y*, vitellarium. × 330.

Fig. 4. Camera lucida drawing of longitudinal section of male copulatory organ. *aph*, aciculophore; *de*, ductus ejaculatorius; *fc*, female genital canal, extended ductus ejaculatorius; *ede*, lying within it (shown by broken lines); *ga*, genital atrium; *m*, muscular penis-bulb; *msp*, muscles of penis-sheath; *s*, spermatozoa in sheaths on way to vesicula seminalis; *s'*, spermatocyte; *sph*, sphincter, that divides penis-bulb from penis; and *vs*, vesicula seminalis. × 600.

Fig. 5. Transverse section of male copulatory organ. *ac*, aciculophore; *c*, cuticular ejaculatory duct of penis; *nac*, nucleus of sheath of aciculophore. × 900.

Fig. 6. A, meiosis in primary spermatocyte; B, secondary spermatocyte dividing. × 1200.

PLATE 4



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SOME OBSERVATIONS ON FRESHWATER ALGAE OF FLORIDA*

By Roy M. Whelden

Plates 5 and 6

Information concerning the freshwater algae of Florida is first noted in Bailey's paper published in 1850. He records the occurrence of 83 algae, nearly all desmids, in the state. Wood (1874) recorded 65 algae, mostly desmids, as occurring in Florida; all but 19 of these had been found earlier by Bailey. Wolle, in 1887, specifically noted 83 algae as having been found by him in Florida collections; very few of these had been noted by Bailey or Wood, so therefore greatly increased the number of algae found in the freshwaters of Florida. Five years later, in his second edition on desmids, Wolle recorded the finding of 92 species and varieties of desmids in collections from Florida. This increased the number of freshwater algae known from this state to 235 species and varieties, some of which were not to survive further study. Johnson, in 1895, noted 12 algae (desmids) from Florida, bringing the total number to 244. The Wests (1897) listed 73 desmids as occurring in material they examined: of these seven are described as new species and three as new varieties.

Borge (1909) found 150 species and varieties present in the large amount of Florida material he had in his American collections of freshwater algae. Of these only 33 had been previously noted as occurring in this region, so the number listed from the state was now increased to about 350 species and varieties. Collins (1909) added many species of green algae to the Florida lists; Tilden (1910) noted that several species of Myxophyceae are found in Florida; and Tiffany (1930) cited many species of *Bulbochaete* and *Oedogonium* found there. In 1930, Miss Brown, studying collections of algae from the southeastern coastal plain, found 54 species and varieties in that part of her material which came from Florida. Twenty-six of these had not been previously noted from Florida. Salisbury, studying collections made in August, De-

* Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, No. 191.

cember, and April, 1932 to 1934, found in them 140 species, varieties and forms, of which he noted 61 to be new additions to the algal flora of this state.

The collections on which the present study was made comprise 65 bottles or cans of material and were made by Mr. E. D. Smith in various places in Seminole and Orange Counties during January, March, and April, 1939. The material was preserved in most cases by formalin, in a few in formal-acetic acid-alcohol killing fluid. Examination has revealed in the material a total of 217 species and varieties, of which 54 are Cyanophyceae, 126 are desmids, and the rest with one exception various Chlorophyceae other than desmids. The one exception is the red alga *Compsopogon coeruleus* (Balbis) Mont. which occurred as the dominant alga in two of the collections. The following seem worthy of note, most of them not having been previously recorded from the region.

MYXOPHYCEAE.

While rarely present in any quantity, members of this group of algae were rather frequently found. The following are noted;

Microcystis pulverea (Wood) Forti. A few colonies were found in sediment.

Aphanocapsa pulchra (Kütz.) Rabenh. Small formless masses occurred in two collections. The cells were 3.5–5μ in diameter.

Aphanothece Castagnei (Bréb.) Rabenh. Rather large colonies of this plant were found at Wekiwa Springs. The cells measured 2.5–3 x 3–6μ.

Chroococcus turgidus (Kütz.) Näg. This common alga occurred in small numbers rather generally.

Gomphosphaeria aponina var. *cordiformis* Wolle. This occurred infrequently in a spring and in a collection from a roadside ditch. Cell measurements were 6–7.5 x 13–16μ.

Coelosphaerium Naegelianum Unger. This occurred abundantly in a brook.

Merismopedia elegans A. Br. This was fairly frequent in the same collection.

M. glauca (Ehrenb.) Näg. While never abundant, this alga was found in a brook and at Rainbow Springs. In these two collections the cells were 5–5.5μ broad. Other colonies collected near Rock Springs were composed of cells quite uniformly 4μ broad. Borge has recorded this from Florida also.

M. punctata Meyen. This was found infrequently in a ditch. The cells were 3μ broad.

Stichosiphon regularis Geitler.

Stichosiphon seems to be a genus of very rare occurrence. Ghose (1924) described the first species, found in India, naming it *Chamaesiphon filamentosa*. Three years later Gardner (1927) described *Chamaesiphon Willei*, a species he found in material from Porto Rico. Geitler (1931) established the genus *Stichosiphon* to receive these two species which he held to be one, *S. filamentosus*, and described another species, *S. regularis*, noting however that it might be identical with Ghose's Indian species, from which it differed only in its smaller dimensions. In 1935, Rao described a third species, *S. indica*, characterized by having hyaline sporangia slightly broader and much longer than those of other species and containing a greater number of endospores.

In the Florida material *Stichosiphon* was found in abundance in all stages of development. The plants occurred most abundantly on *Pithophora* filaments and rather less frequently on plants of *Cladophora* and *Rhizoclonium*. They were 4–5.5μ in diameter and up to 50μ long. All collections in which it was found were made around Rock Springs.

It has been my good fortune to have at hand a large collection of fresh water algae from India. Among these were several gatherings containing an abundance of rather well preserved *Stichosiphon*. One of the collections was marked as *Stichosiphon indica* Rao, the others seem to be *S. filamentosus* (Ghose) Geitler. Examination of all this material and comparison with the Florida plants suggests that they are all of a single species whose sporangia are constant in diameter but variable in length. The Florida material, as well as all others I have examined, agrees well with Geitler's description of *Stichosiphon regularis*, so it is determined as that species. Only after an examination of type material would it be possible to determine if this is identical with *Stichosiphon filamentosus*. Among the specimens, showing abundantly all stages from obovate single-celled forms to sporangia containing up to 15 endospores there were a few in which nearly empty sporangial sheaths remained. Two examples of completely empty sporangia were observed. Spore discharge was generally from the dissolute sporangial apex; rarely the sporangium seemed to break off serially with spore discharge. Fig. 1.

Chamaesiphon incrustans Grun. This occurred in considerable abundance in several places on *Lyngbya* and other algae.

Stigonema flexuosum W. & G. S. West. Many specimens were

found singly, entangled among other algae. The maximum diameter found in any of the plants was 18μ.

Hapalosiphon hibernicus W. & G. S. West. This occurred sparingly. The much branched filaments were 7.5–8.5μ in diameter.

Calothrix (*Homoeothrix*) *juliana* (Menegh.) Kirchn. This alga was abundant in a collection from a coarse gravel bottom at Rock Springs.

Calothrix Braunii Born. & Flah. This occurred quite commonly on various algae.

C. epiphytica W. & G. S. West. This was found infrequently in one collection made at Rock Springs. The maximum diameter of the cells at the base of the trichome was 3.5μ; of the filament, 5.2μ.

Plectonema Wollei Farlow. This alga was found in several collections made at various times at Rock Springs and elsewhere. In all collections, the filaments were from 35–43μ in diameter. It was noted that in many cases some of the collections made in the same locality contained an abundance of material appearing quite identical with the noticeably branched *Plectonema*. Careful examination of these latter collections failed to show a single case of false-branching. Lacking false-branching the latter were determined as *Lyngbya magnifica* Gardner. (q.v.)

Tolypothrix tenuis Kütz. This occurred in one collection.

Scytonema Arcangelii Born. and Flah. This was abundant locally.

Nodularia spumigena Mertens. This formed the major part of one collection made in the Econlahatchee River. The filaments were 9–11μ in diameter.

Anabaena was one of the most frequently occurring of all genera of blue-green algae, being found in nearly one-third of the collections. The following species had all the characters essential for species determination: *A. aequalis* Borge, *A. catenula* (Kütz.) Born. and Flah., *A. flos-aquae* (Lyngb.) Bréb., *A. oscillaroides* Bory, *A. variabilis* Kütz.

Spirulina filaments were found in several collections. As seems the most common occurrence, the filaments were found scattered singly among various other algae. The following species were found:

S. laxissima G. S. West. This species was collected east of Osteen. The trichomes were 0.8–0.9μ in diameter; the spirals were 5.2–5.5μ diameter and separated about 20μ from one another.

S. major Kütz. This species occurred in two collections (March 2

and March 30) at Wekiwa Springs. The trichomes were (1–) 1.5–1.7μ in diameter, the spirals (2.5–) 4–5μ in diameter and up to 6μ apart.

S. princeps W. and G. S. West. This species was collected April 23 from the Withlacootchee River. The trichomes were 4.5–6μ in diameter, the spirals rather uniformly 12μ in diameter and about as far apart. It seems worthy of note that a few of the specimens contained very evident vacuoles: presumably these vacuoles are formed by preservatives on certain filaments. Therefore in this case they can have no taxonomic value. Fig. 2.

Oscillatoria. Of this genus the species occurring most frequently in Florida is *O. princeps* Vauch., reported by both Wolle and Borge. In the present collections it occurred abundantly from almost every locality in which collections were made. Other species found were:

O. amphibia Ag. Solitary filaments occurred infrequently among other algae from Rock Springs; also near Osteen. Diameter 2.5–3μ.

O. Boryana Bory. The spirally twisted solitary trichomes were found infrequently among filaments of *O. princeps* in one collection. Diameter 6–7μ.

O. brevis (Kütz.) Gom., from Wekiwa Springs. Diameter 4–6μ.

O. chalybea Mertens. Diameter 8–12μ. Previously recorded from Florida by Wolle.

O. curviceps Ag. Many single trichomes occurred floating in a pool, among other algae. Diameter 14–16μ.

O. limnetica Lemm. Many long slender trichomes were found floating in a ditch. Diameter 1.4–1.7μ; cells 5–10μ long.

O. proboscidia Gom., from Wekiwa Springs. Diameter 12–16μ.

O. splendida Grev. Diameter 3–4μ. Borge has recorded this from Florida.

Phormidium inundatum Kütz. Several specimens were found in collections from Wekiwa Springs.

P. purpurascens (Kütz.) Gom. Floating in a roadside ditch were several specimens of this plant. The filaments occurred in dense masses, and were composed of cells 1.5–2μ broad and from 1.5–2.5μ long.

P. Retzii (Ag.) Gom. Several small dense mats were found; they were composed of uniformly straight filaments 7μ in diameter, with trichomes 6μ in diameter and cells 5–7μ long.

Lyngbya. The species most commonly found in the present collections was *L. aestuarii* Liebm., previously recorded from Florida by Wolle. Other species found were:

L. aerugineo-coerulea (Kütz.) Gom. This occurred on wet sand and on the edge of a sink hole near Winter Park; and submerged, at Wekiwa Springs. The diameter of the cells was 4–7μ.

L. epiphytica Hieron. Many slender filaments were found at Rainbow Springs, winding tightly around *Lyngbya magnifica* Gardner. Cell diameter 1.5–2μ.

L. magnifica Gardner. Filaments which seem to belong to this plant were found in great abundance in several places; usually *Plectonema Wollei* Farlow was found at the same locality. The only difference distinguishing the two algae seems to be the lack of branching in the *Lyngbya*; in these there was no case of branching in any of the large number examined. The filaments were 34–46μ in diameter, the trichomes 28 to 37μ; the cells 3–8μ long. The very conspicuous sheath varied from colorless to deep yellow. It is possible that these are merely an unbranched condition of *Plectonema.*

L. major Menegh. This was found in a spring. The filaments were 24–30μ in diameter, the trichomes 14–17μ, with cells 2–4μ long. The thick sheaths were colorless.

L. Mertensiana Menegh. This occurred in a roadside ditch and also at Wekiwa Springs. The diameter of the filaments was 10–17μ, that of the trichome 7–13μ.

L. Nordgardhii Wille. Many filaments were found growing in irregularly scattered groups on *Rhizoclonium* filaments gathered at Rainbow Springs. The trichomes were 1.5μ in diameter and surrounded by a very delicate sheath.

L. versicolor (Wartm.) Gom. Cell diameter 3μ.

Schizothria lutea Fremy. A few specimens of an alga which appears to be this one were found floating among other algae. In these specimens the long sparsely branched sheaths were yellowish colored, rarely with the inner layers darker than the superficial layers. Each sheath contained 2–3 filaments 3.5–5μ broad, composed of cells up to 12μ long.

HETEROKONTAE.

Ophiocytium capitatum Wolle. This occurred in a ditch, in small numbers.

CHLOROPHYCEAE.

Palmella mucosa Kütz. This was found floating in a pool.

Gloeocystis ampla Kütz. This was found in small numbers in one collection.

G. gigas (Kütz.) Lagerh.

Tetraspora gelatinosa (Vauch.) Desv.

Microspora stagnorum (Kütz.) Lagerh. This rather common alga appeared in several collections.

Stigeoclonium subsecundum Kütz. The plants were found attached on rocky sandy bottom near Rock Springs.

Coleochaete scutata Bréb. This was of rather frequent occurrence on various aquatic plants.

Cladophora crispata (Roth) Kütz. Many specimens were found, growing attached, at Rock Springs.

Cl. Kuetzingiana Grun. This species occurred in several collections.

Rhizoclonium hieroglyphicum (Ag.) Kütz. This was very abundant, with wide variation in dimensions of cells; from 15–38μ diameter. Previously recorded from Florida by Collins.

R. crispum Kütz. Cells 20–24μ in diameter, 20–30μ long, wall 3μ thick.

Pithophora varia Wille. Many plants were found in good fruiting condition in a collection made in May.

Bulbochaete elatior Pringh. In one collection many plants were found fruiting abundantly.

B. intermedia DeBary. Fruiting plants were found growing on a submerged stump under water in a ditch.

Pediastrum araneosum var. *rugulosum* (G. S. West) G. M. Smith.

Coelastrum cambricum Archer. This was found in a roadside ditch.

Oocystis elliptica W. West. This was found in the same roadside ditch.

Tetraëdron regulare Kütz. This occurred in small numbers in one collection.

Scenedesmus dimorphus (Turp.) Kütz. Specimens were found frequently in all collections from the Econlahatchee River.

Sc. quadricauda (Turp.) Bréb. Specimens occurred in many of the collections, particularly in those from shallow water.

Spirogyra filaments were found in great abundance in many collections, but were usually in a sterile condition. The following species were found in good fruiting condition: *Sp. porticalis* (Müller) Cleve., *Sp. pratensis* Trans., *Sp. submaxima* Trans.

DESMIDIACEAE. 126 species or varieties were found in all; most species occurring in many collections in considerable abundance.

Closterium angustatum Kütz.

C. gracile Bréb.

C. incurvum Bréb.

C. moniliferum (Bory) Ehrenb. This species was extremely common in several collections and encountered quite frequently in nearly one-third of them. In all cases the cells were very uniform in size, being 240–260μ long and having a maximum diameter of 40–58μ.

C. parvulum Näg.

C. pseudodianae Roy.

C. rostratum Ehrenb.

Pleurotaenium Ehrenbergii (Bréb.) deBary var. *granulatum*, var. nov. Membrana granulata, granulae irregularite dispersae. Long. cell. 350–420μ, diam. bas. 26–30μ, diam. apic. 19–22μ. Apical granules 7–8 (3–4 visible in face view). A few cells of this variety occurred in one of the collections. Fig. 6.

Pl. Trabecula var. *hirsutum* (Bail.) Krieger. This was found sparingly in one collection.

Pl. Trabecula var. *rectum* (Delp.) W. and G. W. West. This occurred with the preceding variety.

Pl. tridentulum var. *Borgei* Krieger. A few specimens were found near Rock Springs. Length 340–365μ; diameter at base 12–13μ; diameter isthm. 10–11μ. Fig. 3.

Tetmemorus granulatus (Bréb.) Ralfs.

Tetmemorus laevis (Kütz.) Ralfs.

Euastrum abruptum var. *minor* W. and G. S. West; *E. bidentatum* Nag.; *E. crassum* (Bréb.) Kütz.; *E. denticulatum* (Kirchn.) Gay.; *E. evolutum* var. *Glaziovii* (Börges.) W. and G. S. West; *E. gemmatum* Bréb.; *E. insulare* (Wittr.) Roy.; *E. pulchellum* Bréb. With the exception of *Euastrum crassum*, all the species listed were found infrequently. *Euastrum crassum* occurred in large numbers in one collection.

Cosmarium bireme var. *barbadense* G. S. West. The minute cells were 8μ long, 8–8.8μ broad, and 4.5–5.5 thick. Fig. 5.

C. Blyttii Wille.

C. Cucurbita Bréb.

C. Hammeri Reinsch.

C. humile (Gay) Nordst.

C. impressulum Elfv.
C. margaritatum (Lund.) Roy & Bliss.
C. Meneghinii Bréb.
C. nitidulum DeNot.
C. pachydermum Lund.
C. pseudobroomii Wolle.
C. pseudoprotuberans Kirchn.
C. pseudopyramidatum Lund.
C. punctulatum Bréb.
C. subtumidum Nordst.
The many species of this genus, including those listed above, were found singly, scattered among other algae, and were usually present in some quantity, but in no case abundantly.

Species of *Micrasterias* were frequently found in many of the collections. The following are noted:
M. arcuata var. *robusta* Borge.
M. Crux—melitensis (Ehrenb.) Hass.
M. floridensis Salisbury f. *spinosa*. The few specimens found differed from that figured by Salisbury in having two prominent usually curved teeth on the lateral margins of the polar lobe and two pairs of slightly smaller teeth on the adjoining margin of the lateral lobe. Fig. 8.
M. mahabuleshwarensis var. *serrulata* (Wolle) G. M. Smith.
M. pinnatifida (Kütz.) Ralfs. This desmid occurred in abundance rather generally. It was particularly interesting because of the numerous variations which it showed. The greater part of the specimens were 40–50μ long and 60–70μ broad. Many smaller specimens were seen, some being only 28–33μ long and 35–40μ broad. The smaller specimens were very uniform in appearance. The larger ones were far from uniform, exhibiting great variation in the branching of the ends of the basal lobes and in the occurrence of accessory teeth on the margins of these basal lobes. Similar variations have been noticed occasionally by others: Johnson (1894) in particular has specifically noted that abnormal forms occur more frequently in larger forms of *Micrasterias radiata*. A few of the many variations observed are shown in Fig. 7.
M. radiosa Ralfs.

Arthrodesmus quadridens Wood. This was found infrequently in one collection.

Staurastrum alternans Bréb.

S. ankyroides Wolle.

S. Arctiscon (Ehrenb.) Lund.

S. Arctiscon var. *glabrum* W. and G. S. West.

S. cuspidatum Bréb.

S. grallatorium var. *quadratum* Irénée-Marie.

S. iotanum Wolle.

S. muticum Bréb.

S. paradoxum var. *parvum* W. West.

S. tetracerum Ralfs.

S. pentacerum var. *tetracerum* (Wolle) G. M. Smith; with zygospore. The spherical zygospores are about 35μ in diameter, and bear several straight to slightly curved simple spines about 20μ long. Fig. 4.

CHARALES.

Chara fragilis Desvaux. This occurred in fruiting condition in one collection. Fragments and sterile plants of this genus and of *Nitella* were very frequently found.

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EXPLANATION OF PLATES 5 AND 6

Figure 1. *Stichosiphon regularis* Geitler.
Figure 2. *Spirulina princeps* W. and G. S. West.
Figure 3. *Pleurotaenium tridendulum* var. *Borgei* Krieger.
Figure 4. *Staurastrum pentacerum* var. *tetracerum* (Wolle) G. M. Smith. Zygospore.
Figure 5. *Cosmarium bireme* var. *barbadense* G. S. West.
Figure 6. *Pleurotaenium Ehrenbergii* (Breb.) DeBary var. *granulatum* var. nov.
Figure 7. *Micrasterias pinnatifida* (Kütz) Ralfs.
Figure 8. *Micrasterias floridensis* Salisbury f. *spinosa*.

PLATE 5

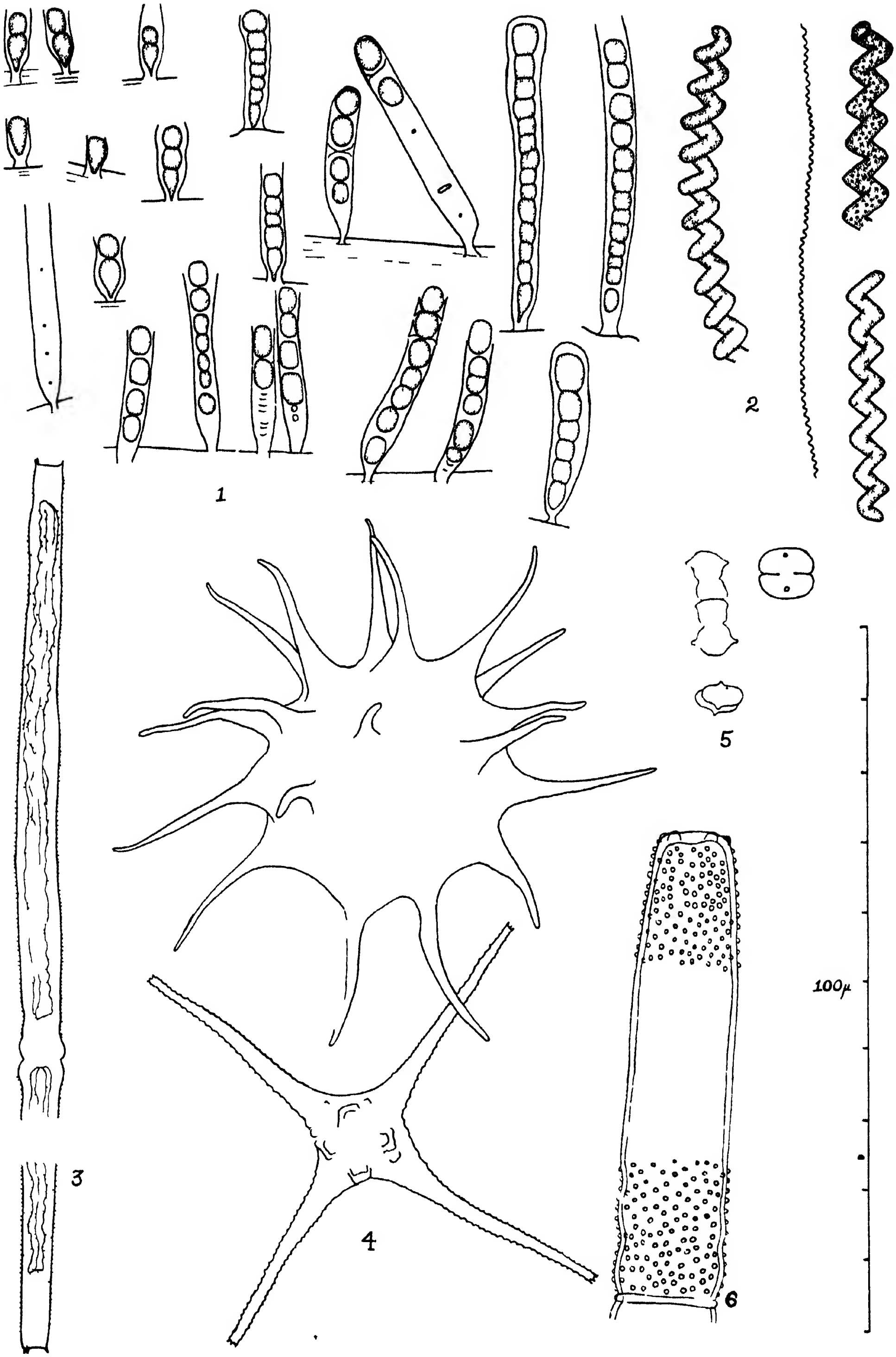
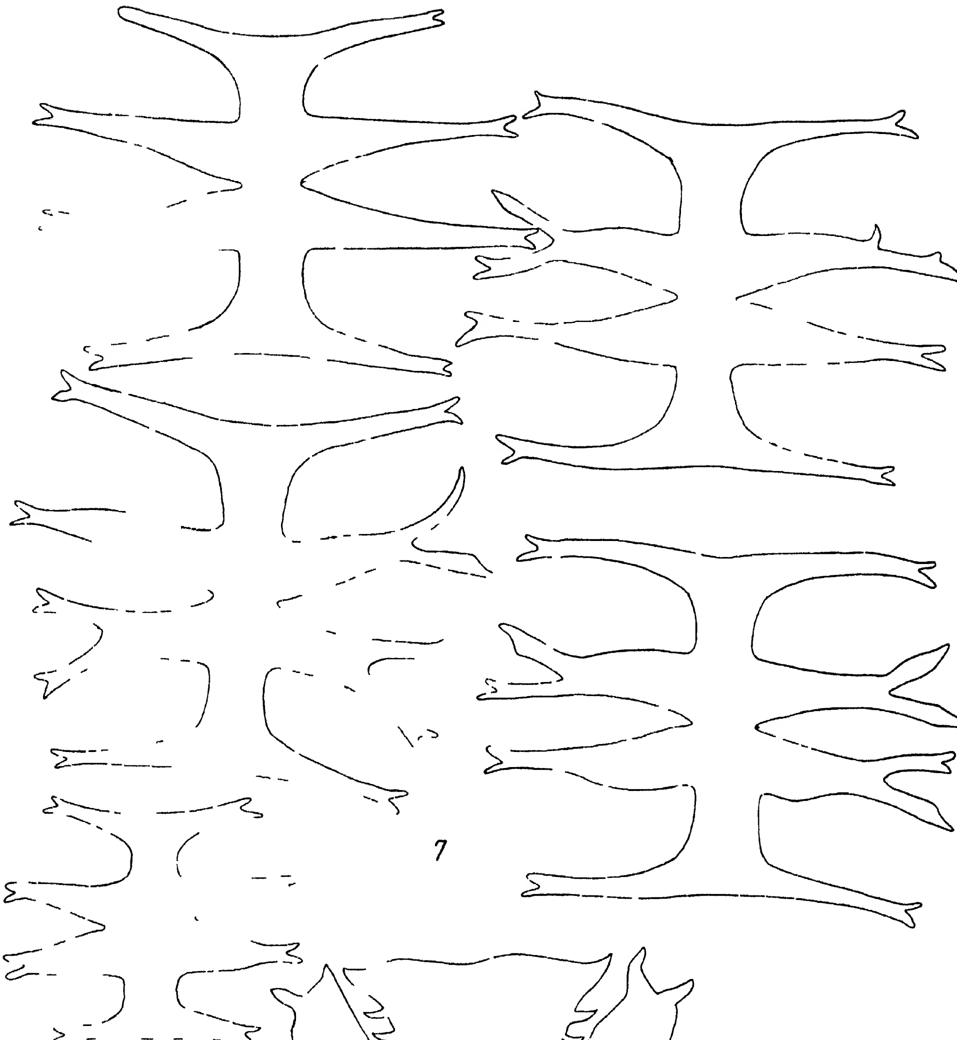


PLATE 6



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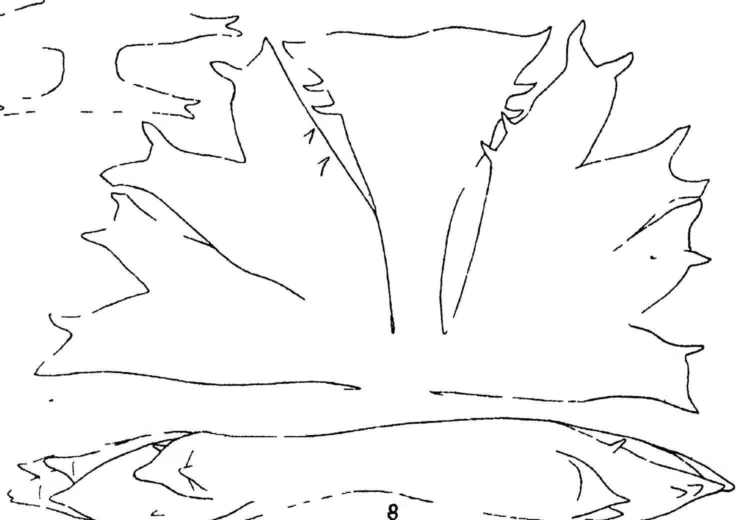

8

POLYDORA, A PEST IN SOUTH CAROLINA OYSTERS

By G. Robert Lunz, Jr.

Two Text Figures

In 1935, South Carolina oysterman first called my attention to irregular-shaped, dark brown blisters on the inner surface of the shell of oysters. One oysterman in particular stated that the presence of these blisters in increasing numbers was seriously damaging his business by causing the yield of oyster meats secured from raw oysters to be considerably lowered.

With this incentive, a study was begun of mud blisters in oysters along the South Atlantic Coast and particularly in South Carolina. This paper is the result of that study.*

As in most investigations of this sort, the author owes a debt of gratitude to many for active assistance, criticism, and suggestions. First, I want to express my appreciation to the South Carolina Academy of Science for awarding me the research grant of the American Association for the Advancement of Science which has helped cover expenses during the past year. Most sincere thanks are expressed to Dr. Olga Hartman of the Allan Hancock Foundation for her work in identifying the organism which causes the mud blister. Finally my indebtedness is gladly acknowledged to the many others who have assisted in one way or another. Foremost among these are: my colleagues at The Charleston Museum; Dr. J. C. Medcof of the Fisheries Research Board of Canada; Dr. Paul S. Galtsoff of the U. S. Fish and Wild Life Service; Dr. Waldo L. Schmitt of the U. S. National Museum; the officials of the Shelmore Oyster Products Company; and the officials of the L. P. Maggioni Company.

MUD BLISTERS

That oysters have long been infested with mud blisters has been shown (Lunz, 1940) by their presence in oyster shells collected from an Indian village site known to have been occupied prior to 1500 A.D. Recently

* This paper received the Jefferson Award for the best paper presented at the meeting of the South Carolina Academy of Science in April, 1941.- Ed

samples taken from shell deposits suspected of belonging to the Pleistocene era also showed heavy infestation of mud blisters.

FIGURE 1. Mud blisters in upper valve of an oyster

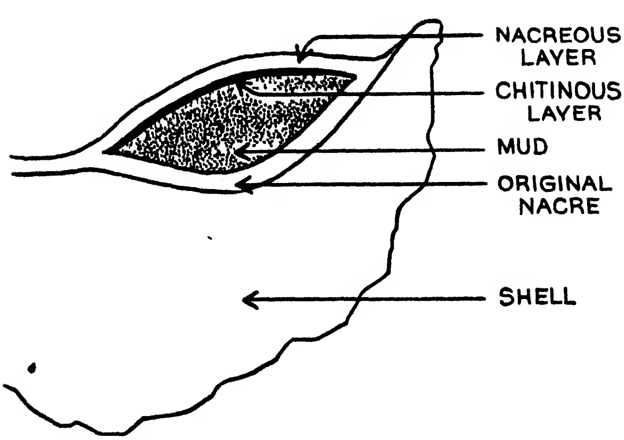

FIGURE 2. Diagrammatic section through shell and mud blister.

Mud blisters appear as brown, irregular, flattened bumps on the inner surface of the shell of oysters. The actual appearance of a mud blister can best be described by the use of an illustration. Examine the photo-

graph given as Figure 1. Here are several mud blisters lying along the edge of the upper valve of an oyster. Note the irregular shapes of the mud blisters. The two blisters on the extreme right of the picture overlap on their inner ends. These two blisters are about typical in shape and size. Figure 2, a diagrammatic drawing, shows the structure of the blister. A thin layer of nacre overlies the entire blister. Beneath this nacreous layer is a thin brown chitinous layer which is apparently secreted by the oyster before the nacre is laid down. Under this chitin or chitinous-like layer is a daub of mud within which lies the causative organism, *Polydora ciliata.* Mud blisters almost invariably continue to the outer edge of the oyster and communicate with the outside. The blister on the extreme right of Figure 1 has the nacreous layer crushed in over that part of the blister leading to the outer edge of the shell of the oyster and shows distinctly the double canal through which the worm communicates with the outside environment.

The manner in which a mud blister is formed within the shell of an osyter is discussed in detail by Whitelegge (1890) for Australian oysters and to some extent by Kavanagh (1940) for Japanese oysters in Louisiana waters. Apparently from these reports and from observations, the worm simply swims into the oyster when the valves are open for feeding and then secures a favorable position in the shell. Within a very short time (about an hour, according to Whitelegge, 1890, p. 45) the worm has collected a blob of mud around itself. The oyster immediately begins to secrete the chitin-like layer over this irritating mass and rapidly (some observations would indicate within a twenty-four hour period) the mud and the worm are covered over. At a somewhat slower rate the mud and the chitinous layer are covered with nacre. The worm meanwhile has constructed the two canals to the outside. These canals always have been found present in mud blisters in which living worms are found. In innumerable cases the canals have all the appearances of being cut or etched into the nacreous layer of the oyster on which the mud blister is formed. Lankester (1868) has suggested that Polydora can secrete a powerful acid which would of course account for the formation of the canals.

The causative organism of the mud blister has been identified by Dr. Olga Hartman as *Polydora ciliata* Johnston. This organism is an annelid worm belonging to the order Polychaete and the family Spionidae. The worm is cylindrical, about one-half inch long, consists of some 40 segments, is yellowish or flesh-colored with a red line down

the middle. There are no tentacles or palps but the anterior end bears a pair of long peristomial cirri. The parapodia are small. The fifth segment of Polydora is characteristic, being longer than the others and bearing peculiar setae, obtuse and curved like an italic *f*.

EFFECT OF MUD BLISTERS ON OYSTERS

Since Polydora is confined within the mud blister and does not come into contact with the actual meat of the oyster, it would be natural to expect that the effects of infestation by the worm on an oyster would be less severe than in the case of an active inter- or intracellular parasite. In fact, Polydora should not be considered as a parasite in oysters except in the general way that it lives with an oyster, incurring advantage from the protection of the oyster shell without compensation to the oyster. Polydora exerts no toxic effect on the oyster and of course does not subsist on the tissue of the oyster. As has been shown, the worm is entirely walled out from the oyster meat and infestation by Polydora in no way renders the oyster unfit for food.

The primary effect of mud blisters on oysters is that these mud blisters (i.e., the worm which causes them) upsets the normal life of the oyster by restricting its living space and forcing the oyster to devote considerable of its energy in shell building which otherwise would be unnecessary. Commercially, infested oysters are not as readily salable because of their unpleasant appearance (see Lunz, 1940).

In addition to these personally observed undesirable effects, Whitelegge (1890) reports the death of oysters in Newcastle, Australia, from mud blisters. Lebour (1906) reports *Polydora ciliata* as a "real evil" in mussels in England. Roughley (1925) calls Polydora "the greatest enemy of the oyster" on the coast of New South Wales. Further, as shown in the introduction, at least one South Carolina oysterman believed that the presence of mud blisters caused him considerable loss.

In the five year period during which these pests have been under observation in South Carolina and other southern states, no high mortality has been found on oyster beds which could be attributed to the activities of Polydora. Although Polydora is a pest and could be considered as a "real evil," certainly it has not yet become the greatest pest of oysters along the South Atlantic Seaboard.

The belief of the oysterman that the yield in oyster meats is lowered by the infestation of Polydora has been investigated. A random sample of a standard bushel of shell was taken from the shell piles of an oyster canning factory in Charleston County, South Carolina. Samples were obtainable over a ten year period with the exception of a few years. The

shells were examined and the presence or absence of mud blisters was noted. Also the yield of oyster meats per bushel of oysters for this same factory for the same years was obtained from the South Carolina State Board of Fisheries. Table 1 gives these data.

Table 1 certainly does not show any marked correlation between the percentage of mud blisters present and the yield of oyster meats per bushel. However, since there are so many factors involved in the yield of oyster meats per bushel as determined by an oyster factory (see Lunz, 1938, p. 105–110), the data presented in Table 1 should not be used to conclude that mud blisters have no effects on yield.

TABLE 1

Percentage of mud blisters per bushel of shell compared with ounces of oyster meats yielded per bushel of oysters

OYSTER SEASON	PERCENTAGE OF MUD BLISTERS	YIELD IN OZ. PER BUSHEL
1930–31	21.39	35.76
1932–33	23.99	37.76
1934–35	29.48	32.40
1935–36	28.48	35.57
1936–37	30.00	35.95
1937–38	29.92	32.61
1939–40	15.09	36.33

From observations made on approximately 9,000 oysters opened and examined in connection with this investigation, the general conclusion is that many of the oysters are in a poor and watery condition when they are heavily infested with mud blisters. Many methods were tried to arrive at some mathematical expression which would indicate the poorness or fatness of oysters so that the effects of mud blisters on the condition of oysters could be stated concisely and definitely. No method has been found which is perfectly satisfactory.

However, Dr. J. C. Medcof of the Fisheries Research Board of Canada kindly suggested a method of determining the condition of fitness of oysters. Just recently (August 1941) Medcof and Needler have published a paper on "The Influence of Temperature and Salinity on the Condition of Oysters (*Ostrea virginica*)" in the Journal of the Fisheries Research Board of Canada, and on page 253 they give the formula for determining the fitness of oysters. This formula is given thus:

$$1000 \times \frac{\text{Dry weight of the oyster meat in grams}}{\text{Volume of the space between the valves in millilitres}}$$

Computations by this method give an abstract figure which can be used for comparisons in different localities.

In all, 67 oysters were analyzed by the Medcof method. The result of these analyses shows that oysters without mud blisters or with only one blister are 14% more fit than those with two or more blisters. Before this percentage can be accepted as invariably correct, further work must be done. Nevertheless, from analyses so far made, the indications are that infestation of oysters by Polydora causes a loss of weight in oysters.

DISTRIBUTION

According to Dr. Olga Hartman, *Polydora ciliata* is practically universally distributed. As for infestation of oysters by Polydora, Whitelegge (1890), Lebour (1906), Roughley (1925), and others have reported infestation in oysters or closely allied Mollusca in other countries. *Polydora ciliata* apparently was not reported as a pest in oysters in the United States until the author reported them in a preliminary paper to this study published in October 1940. However, mud blisters (without the causative worm having been identified) had been discussed at some length by the author in a report published in January 1938, and in October 1938 Dr. A. S. Pearse noted the occurrence of an unidentified Polydora in two oysters in the Apalachicola region of Florida. Now I have evidence or have reports of infestation throughout the entire range of *Ostrea virginica* in North America. I have specimens of infested oysters from Prince Edward Island, Canada, the northern limit of the range of the eastern oyster, and I have reports of infested oysters in Texas. In addition, either specimens or reports (mainly correspondence) exist of infested oysters for Long Island Sound, Chesapeake Bay, North Carolina, South Carolina, Georgia, Florida, and Louisiana.

Samples of oysters have been taken practically throughout the length of the oyster-producing areas of South Carolina. Oysters were found to be infested with mud blisters from one end of the coast to the other.

In the Santee River area, from McClellanville northward, oysters were examined in 18 places. A total of 1335 oysters were opened and examined, and of this number 80.03% were infested with mud blisters. In this area the water is muddy, the bottom is soft and, in all but four of the places where examinations were made, the oysters were tonged from below low water mark. Here the salinity of the water is usually low (for South Carolina), ranging from 5 to 20 parts per thousand. For a fuller account of salinity for coastal South Carolina north of Charleston see Lunz (1938).

In the Bulls Bay section 532 oysters were examined in 4 different places. Infestation by Polydora here was found to be 64.69%. In general, the bottom was soft and most often muddy. All oysters were collected above low water mark. The salinity usually ranges from 14 to 32 parts per thousand.

In the Bullyard Sound area, lying about half-way between Charleston and the Santee River, oysters grow largely above low water mark and in thick clusters. Here the percentage of infestation, as determined by the examination of 114 oysters gathered at 3 different places, was only 16.19%. The salinity of the water in this section ranges from 32 to 33 parts per thousand.

Three localities were examined in the vicinity of Charleston. Here the oysters were collected above low water mark on bottom that was not hard but which was considerably less muddy than in the Santee River area. In all, 387 oysters were examined and the infestation by Polydora was found to be 36.38%. Salinity in this area varies from 25 to 33 parts per thousand.

From one sample of 15 oysters taken from the wharf of an oyster canning factory at Yonges Island, South Carolina, the percentage of infested oysters for that area would be 33.33%. However, the sample is small and may not be truly indicative of that area. By their appearance these oysters were all taken above low water mark. The area would in general correspond to the Bullyard Sound area both in condition of bottom and in range of salinity.

A sample of commercial oysters bought from an oysterman who collects his oysters in the creeks of Edisto Island, showed that out of 87 oysters examined the infestation was 76.48%. With few exceptions these oysters had the appearance of having been collected below low water mark. In most of the creeks in the vicinity of Edisto Island the salinity ranges from 18 to 32 parts per thousand.

One lot of 167 oysters was examined at a raw shuck oyster plant near Beaufort. The oysters were said to have been gathered in the Coosaw River. These oysters showed a 42.57% infestation. The oysters were all large and single and quite evidently had been taken off firm bottom but below low water mark. The salinity for this area varies from 25 to 32 parts per thousand.

COMPARATIVE PERCENTAGE OF INFESTATION

In addition to the oysters opened and examined as mentioned above, representative samples of oyster shells were taken from shell piles of various oyster factories. A standard bushel of shell was examined in

each case and the percentage of infestation determined from the presence or absence of mud blisters in the individual valves. The percentages obtained by examining complete oysters of two valves are not directly comparable with percentages obtained from examining the shells at the canning factories where only one valve entered into the count. In the samples from the factories the lower valves of the oysters were in preponderance. However, the percentages obtained from the factories are perfectly comparable among themselves and the increase or decrease in the percentage of infestation for different years can be determined from these counts. Table 2 gives the percentage of infestation for the

TABLE 2

Percentage of infestation of oyster shells at different oyster canning factories

FACTORY	AREA	PERCENTAGE OF INFESTATION			
		*	1936-37	1937-38	1939-40
1	Santee River to Charleston	25.81	30.00	29.92	15.09
2	Charleston to St. Helena Sd.	—	17.65	—	14.60
3	St. Helena Sd. to Port Royal Sound	—	28.58	—	20.64
4	St. Helena Sd. to south of Broad River	—	34.62	—	—
5	May River and Calibogue Sd.	—	34.00	26.48	27.38
6	Northeast Georgia, southwest of Savannah	—	31.36	—	28.52
7	Vicinity of Mayport and of Amelia City, Fla.	—	—	—	34.50

* Average of four years from 1930 to 1936.

different regions as determined from the examination of the shell piles of the different factories.

DISCUSSION

An examination of the data given under *distribution* above and field notes made when samples of oysters were taken to determine the percentage of infestation in South Carolina show that Polydora was present in 49.97% of the oysters growing above low water mark and in 85.86% of the oysters growing below low water mark.

In South Carolina, although not universally so, in most cases where oysters are found growing to any appreciable depth below low water mark, the salinity is low. There are not enough data to separate the effects of low or high salinity from the effects of depths at which oysters

grow. Generally speaking, however, Polydora is more prevalent in waters of low salinity.

Further examination of data presented and field notes indicate that on firm or hard bottom above low water mark 20.90% of the oysters were infested with Polydora. On muddy or soft bottom above low water mark the infestation was 51.93%.*

Additional observations made recently in Duval County, Fla., substantiate fully this claim that Polydora is more prevalent on soft and muddy bottom.

The fact that mud blisters are more common in oysters growing below low water mark makes Polydora a more serious pest in South Carolina waters. Here the better grades of oysters cannot be grown above low water mark (a few isolated cases excepted) because of the enormous set of young oysters yearly. Production of large, select, single oysters for the half-shell retail trade must be almost entirely confined to areas below low water mark where, unfortunately, the worms causing mud blisters are more numerous. The presence of mud blisters in an oyster takes it out of the better class of select, single oysters. Thus exists a vicious circle.

The evidence presented from analyses by the Medcof method of determining the condition of fitness of oysters, although admittedly not as complete as it could be, is important. Any loss of weight in oyster meats is extremely important to an oyster canning factory when it is realized that a single oyster canning factory in South Carolina will use 150,000 to 200,000 bushels of oysters in a season and secure a yield of from 5,000,000 to 7,000,000 ounces of oyster meats.

The investigation has one cheerful side. The percentage of infestation of oysters by Polydora does not seem to be increasing. Oysters taken from an Indian mound in South Carolina, known to have been constructed prior to 1500 A.D., show a 21.90% infestation. Oysters from a stratum near the mouth of the St. Johns River, Fla., suspected of being Pleistocene, showed a 54% infestation. The 23.45% infestation for the 1939–40 season (average of last column, Table 2) is practically

* The apparent discrepancies in the total of the percentages given in the paragraphs above are due to the fact that the percentages were obtained from different data. Many of the observations made in 1936 show only that the oysters were gathered below or above low water mark and no notes were made at the time on the condition of the bottom. Thus, in calculating the percentages for infestation on soft or muddy bottom, for example, many observations which entered into the percentages obtained for oysters growing above the low water mark could not be used.

the same as that found in oysters taken from the Indian mound and lower than the percentage of infestation in the shells from the St. Johns River stratum. Thus it would seem that *Polydora ciliata* has reached its level of normal abundance in South Carolina waters. Sufficient data are not available to determine whether or not the percentage of infestation in Florida waters has increased or decreased in recent years, but now the infestation is about 19% lower than that found in the so-classified Pleistocene stratum.

CONCLUSIONS

From the observations made and the data given in this report, the following conclusions can be made:

(1) The average percentage of infestation of oysters by Polydora is high in South Carolina, being about 40%.

(2) The number of oysters infested by Polydora is not increasing in South Carolina.

(3) Infested oysters appear to be poorer than uninfested oysters, but the loss in weight can not be determined from the examination of canning factory yields. The application of Medcof's method of determining fitness in oysters tends to substantiate the observation that infested oysters are poorer.

(4) Polydora is more prevalent below low water mark, on soft bottom, and in areas of low salinity.

(5) The better grade, select oysters for the half-shell trade will be hard to produce as long as a high percentage of infestation by Polydora exists.

CHARLESTON MUSEUM,
CHARLESTON, S. C.

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A NEW GEOMETRICAL INTERPRETATION OF EINSTEIN'S SPECIAL RELATIVITY THEORY

By Archibald Henderson

Plate 7

The foundation of the Special Relativity Theory was laid by Albert Einstein in 1905 in his classic paper, "On the electro-dynamics of moving bodies."[1] In the derivation of the famous formulas for Special Relativity, Einstein had been anticipated eighteen years by W. Voigt, who introduced the concept of "local time" in a mobile system and thereby established the validity of the wave-equation

$$\Delta\phi - \frac{1}{c^2}\frac{\partial^2\phi}{\partial t^2} = 0$$

in the mobile system.[2]

In several fundamental papers in the field of electromagnetism, H. A. Lorentz independently arrived at the same transformation, and thereby established the physical equivalence of the moving and the stationary systems, with rectilinear motion and constant relative velocity.[3] In 1909 Lorentz stated that Voigt's paper, above cited, had hitherto escaped his attention; and makes the following specific acknowledgment: "The idea of the transformation might therefore have been borrowed from Voigt, and the proof that it does not alter the form of the equations for the free ether is contained in his paper."[4]

Lorentz was attached to the classic, pre-relativistic concepts, in that

[1] Annalen der Physik, vol. XVII, p. 891.

[2] W. Voigt: "Ueber das Doppler'sche Princip." Gottinger Nachrichten, 1887, p. 41.

[3] H. A. Lorentz: "La théorie éléctromagnetique de Maxwell et son application aux corps mouvants," Arch. Néerl. 25 (1892), p. 363; "Versuch einer Theorie der elektrischen und magnetischen Erscheinungen in Bewegten Korpern" (Leyden, 1895); "Electromagnetic phenomena in a system moving with any velocity smaller than that of light," Proc. Amsterdam Acad. VI (1904), p. 809.

[4] "The Theory of Electrons" (Leipzig: Teubner, 1909), p. 198. This book embodies the substance of a series of lectures delivered at Columbia University in 1906.

he employed a privileged system, namely one "fixed in the ether." Einstein began by denying the existence of any privileged system in space and interpreted the two systems involved as having perfect reciprocity. In view of this essential character of reciprocity, this first special theory of relativity might more fittingly have been termed the theory of correlativity. In the sequel the transformation for two inertial systems, namely moving rectilinearly with uniform relative velocity, will be denominated the Voigt-Lorentz transformation. Einstein treated these equations as linear transformations in pseudo-Euclidean space-time, adjusting the time and space co-ordinates in such a manner as to establish the invariance of light velocity.

The following form of the Voigt-Lorentz transformation is sufficiently general for illustrative purposes:

$$x = \alpha(x' - vt), \qquad y = y', \qquad z = z', \qquad t = \alpha\left(t' - \frac{vx'}{c^2}\right) \quad ..(1)$$

$$\alpha = (1 - v^2/c^2)^{-1/2}.$$

where v is any real constant less than c, the velocity of light (186,000 miles per second, approximately).

It is easy to show that

$$c^2t^2 - x^2 - y^2 - z^2 = c^2t'^2 - x'^2 - y'^2 - z'^2 = s^2,$$

let us say; and in the infinitesimal region, because of the linearity of the equations

$$c^2\,dt^2 - dx^2 - dy^2 - dz^2 = c^2\,dt'^2 - dx'^2 - dy'^2 - dz'^2 = ds^2 \quad \ldots (2)$$

The term "interval", or "separation" (we shall use the former, here) is employed for the invariant

$$ds = \sqrt{c^2\,dt^2 - dx^2 - dy^2 - dz^2} \quad \text{or} \quad \sqrt{dx^2 + dy^2 + dz^2 - c_2dt^2} \quad .\,(3)$$

When time is not involved, it is clear from the second form of (3) that the interval reduces to the distance, except for an extraneous factor. In the treatment which follows, equations (1), omitting $y = y'$, $z = z'$, are employed.

Since the appearance of Einstein's paper of 1905, cited above, efforts have been made to arrive at geometrical interpretations of the Voigt-Lorentz transformation. An enlarged conception, but no real simplification, was effected by Poincaré who in 1906, in a treatment of the dynamics of the electron and the subject of universal gravitation, in-

terpreted the Voigt-Lorentz transformation as a rotation in space through an imaginary angle.[5] A year later Minkowski put forward the same interpretation;[6] but in subsequent papers he advanced his ingenious and fruitful conception of world-lines and the light-cone. The case for two dimensions is that of a rectangular hyperbola $c^2t^2 - x^2 = 1$, the Voigt-Lorentz equations constituting the transformation from this form to $c^2t'^2 - x'^2 = 1$, being the same curve referred to a (non-perpendicular) pair of conjugate diameters.[7]

In 1925 Bertrand Russell sketched in outline an elementary geometrical treatment of Special Relativity.[8] In 1936 the present writer gave a detailed geometrical treatment of the Voigt-Lorentz transformation, with a derivation of the absolute and relative invariants, by the use of hyperbolic functions.[9]

The essential problem of Special Relativity may be illustrated in the simplest form by means of a mechanical device. Imagine a very wide, slightly corrugated, steel belt, moving horizontally with uniform velocity; and a passenger, standing on the belt and stationary thereto, who is being carried forward with uniform velocity by the moving belt. Suppose now a motor car runs on to this wide belt and moves with uniform velocity, say faster than the belt is moving. Eventually the motor car passes the passenger who is being carried along by the belt.

Before the experiment begins, that is before the passenger walks onto the belt and the chauffeur drives the car onto the belt, the passenger and the chauffeur compare their instruments for measuring space and time while they are at rest. Each carries a yardstick and a watch. They compare their yardsticks with a standard yardstick; and each finds that his own yardstick is exactly one yard long. They then compare

[5] H. Poincaré: "Sur la dynamique de l'éléctron," Rend. del Circolo Mat. di Palermo, vol. xxi, p. 129.

[6] H. Minkowski: "Grundgleichungen für die elektromagnetischen Vorgänge in bewegten Körpern," Gött. Nach. 1908, p. 53; "Das Relativitätsprinzip," Vortrag gehalten in der Math. Gesellsch. zu Göttingen, November 5, 1907, published in Jahresber. d. Deutsch. Math. Ver. **24** (1915), p. 372, and in Ann. d. Physik. **47** (1915), p. 927.

[7] H. Minkowski: "Grundgleichungen für die elektromagnetischen Vorgänge in bewegten Körpern," Math. Ann. **68** (1910), p. 472; "Raum und Zeit," lecture delivered during the meeting of the "Naturforscherversammlung" at Cologne, September 21, 1908, and printed in Physik. Zeitschrift **10** (1909), p. 104.

[8] The ABC of Relativity (Harper and Brothers: New York and London, 1925), pp. 86–90.

[9] Archibald Henderson: "New Aspects of Relativity: Geometrical Treatment of the Voigt and Page Transformations," Journal of the Elisha Mitchell Scientific Society **52**, No. 1 (July, 1936), pp. 1–19.

their watches and regulate them so that they run regularly and synchronously; that is, so that if one watch at a given instant records ten minutes past noon, the other watch simultaneously records ten minutes past noon.

The problem of Special Relativity, briefly stated, is to correlate the measurements which the passenger and the chauffeur each makes in space and time with his own particular yardstick and watch. We wish to find formulas, that is equations expressed in both space- and time-variables, which will enable the passenger on the belt, after measuring a length along the belt in the direction of the belt's motion and recording the time when this measurement is made, to state exactly the distance and time the chauffeur finds this same distance and this same time to be, by using his own yardstick and watch; and vice versa.

These measurements are supposed to be made by the passenger and the chauffeur, while each remains in the situation described above: namely, the passenger remaining glued to the belt and the chauffeur remaining glued at the wheel of the car. If we solve the problem correctly, then each man will be able to tell from his own measurements what the other man's measurements will give, just as an engineer, after reading a graduated stadia rod through his telescope, can tell how far away the rod actually is. Each man, of course, knows the velocity of the belt, the velocity of the motor car with reference to the belt, and the velocity of light (c = 186,270.75 miles or 299,774 kilometers per second are highly accurate values).

The present method, given below, enables one, after drawing to scale a given chart according to definite directions, to scale off with ruler and compasses the requisite quantities for obtaining a complete solution of the problem. The chart enjoys the superiority over ordinary computation which is supplied, for example, by a vernier or a slide-rule. In simplicity and efficiency, this technic for interpreting and employing Einstein's Special Relativity Theory is, it is believed, superior to any other yet devised. This chart does, both in theory and practice, make Relativity easy.

The new geometrical treatment of the Special Relativity Theory differs in important respects from other disciplines. The postulates set up are the following, one of which only is the same as one of the two fundamental postulates usually employed:

POSTULATE 1. The velocity of light in free space appears the same to all observers, regardless of the relative motion of the source of light and the observer in the inertial system.

POSTULATE 2. For two inertial systems, moving rectilinearly

with uniform relative velocity, the interval for two events, as expressed in the co-ordinates of the two systems, is formally and absolutely invariant.

In former treatments of the problem confronted here, two co-ordinates for space and time respectively, x and t, are employed, either represented along the same line, or along two mutually perpendicular lines. The co-ordinates employed in the present paper are T and T', representing "slow motion" times, where $T = ct$, $T' = ct'$, t and t' being the times in the two moving systems, and c the velocity of light. The T- and T'-axes are taken to be mutually perpendicular.[10]

Consider the following curve

$$T^2 - 2\alpha TT' + T'^2 + \frac{\alpha^2 v^2}{c^2} s^2 = 0 \qquad (1)$$

where $\alpha = +\left(1 - \frac{v^2}{c^2}\right)^{-1/2}$, c is the light-velocity, $v < c$ and $s > 0$. Since $h^2 - ab$, viz. $\frac{\alpha^2 v^2}{c^2} > 0$, this curve is an hyperbola. This curve may be written in the form

$$T' = \alpha T \pm \frac{\alpha v}{c} \sqrt{T^2 - s^2} \qquad (2)$$

Let us confine our attention to that portion of one branch of the curve denoted by

$$T' = \alpha T - \frac{\alpha v}{c} \sqrt{T^2 - s^2} \qquad (3)$$

viz. traversing that part of the curve from A in a counter-clockwise direction.

Assume further that

$$T = ct, \qquad T' = ct' \qquad (4)$$

where t and t' are the times in the two inertial systems, moving rectilinearly with uniform relative velocity v to each other.

[10] The choice of Postulate 2, above, as one of the two fundamental assumptions of Special Relativity was suggested by a student, C. H. Frick, then instructor in the Montana State College, while attending the writer's class in Special Relativity during the Summer (1940) Quarter at the University of North Carolina. This suggestion is in line with arguments advanced by Sir Arthur Stanley Eddington and Dr. George D. Birkhoff. Consult Eddington, The Mathematical Theory of Relativity (Cambridge University Press, 1923) and Birkhoff, Relativity and Modern Physics (Harvard University Press, 1923).

According to Postulate 2, we have

$$c^2t'^2 - x'^2 = c^2t^2 - x^2 = s^2, \text{ say,}$$

or

$$s^2 = T'^2 - x'^2 = T^2 - x^2 \qquad (5)$$

using equations (4). Hence

$$T^2 - s^2 = x^2 \qquad (6)$$

The vertical tangent touches the hyperbola at the point $A(s, \alpha s)$. From (3) and (5) we have

$$T' = \alpha\left(T - \frac{v}{c}x\right) \qquad (7)$$

Then from (5) and (7) we have

$$x'^2 = T'^2 - T^2 + x^2 = \alpha^2\left(T^2 - \frac{2v}{c}xT + \frac{v^2}{c^2}x^2\right) - T^2 + x^2$$

$$= \left(1 + \alpha^2\frac{v^2}{c^2}\right)x^2 - 2\alpha^2\frac{v}{c}xT + (\alpha^2 - 1)T^2$$

$$= \left(1 + \frac{v^2}{c^2\left(1 - \frac{v^2}{c^2}\right)}\right)x^2 - 2\alpha^2\frac{v}{c}xT + \alpha^2\left(1 - \frac{1}{\alpha^2}\right)T^2$$

$$= \alpha^2x^2 - 2\alpha^2\frac{v}{c}xT + \alpha^2\left(1 - 1 + \frac{v^2}{c^2}\right)T^2$$

$$= \alpha^2\left(x^2 - 2\frac{v}{c}xT + \frac{v^2}{c^2}T^2\right) \therefore x' = \pm\,\alpha\left(x - \frac{v}{c}T\right) \qquad (8)$$

Let us choose here

$$x' = \alpha\left(x - \frac{v}{c}T\right) \qquad (9)$$

The line OA is

$$T' = \alpha T \qquad (10)$$

with the slope

$$\tan\theta = \alpha. \qquad (11)$$

For some assumed value of s, we may assign values of T and derive the corresponding values of x from (6), for a given velocity v and known

value of c; and thence derive the corresponding values of T'. From these values of T and T' the curve may be readily drawn. For the diagram (Plate 7), the following values are taken: $s = 6$, $v = 180{,}000$ kilometers per second, $c = 300{,}000$ kilometers per second. The hyperbola is

$$\frac{4}{81}x^2 - \frac{10}{81}xy + \frac{4}{81}y^2 - 1 = 0$$

The axis of vertical symmetry is $y = x$ which meets the curve in the point $(\frac{9}{2}\sqrt{2}, \frac{9}{2}\sqrt{2})$. The chosen fixed point P, (T_1, T_1') on the hyperbola is (8, 6.5). The corresponding values of x and x' are 8 and 2.5; and $\alpha = \tan\theta = (1 - \frac{9}{25})^{-\frac{1}{2}} = \frac{5}{4}$.

Through P_1 draw vertical and horizontal lines, the former meeting the T-axis and OA in N and M (not shown in figure), and the latter meeting the T'-axis in K. Now $NM = \alpha T_1$, $T_1' = NM - P_1M = \alpha T_1 - P_1M$. Comparing with (7) we have $PM_1 = \frac{\alpha v}{c}x$. If P_1K meet OA in L, we have $LP_1 = \frac{v}{c}x$, since $\tan \measuredangle LMP_1 = \tan\theta = \alpha = \frac{P_1M}{LP_1} = \frac{\frac{\alpha v}{c}x}{LP_1}$.

Now let us construct the five circles

$$T^2 + T'^2 = s^2 \qquad \ldots\ldots (C_1)$$

$$\left(T - \frac{T_1}{2}\right)^2 + T'^2 = \left(\frac{T_1}{2}\right)^2 \qquad \ldots\ldots (C_2)$$

$$(T - T_1)^2 + T'^2 = x^2 \qquad \ldots\ldots (C_3)$$

$$(T - T_1)^2 + T'^2 = T_1^2 \qquad \ldots\ldots (C_4)$$

$$T^2 + (T' - T_1')^2 = x'^2 \qquad \ldots\ldots (C_5)$$

where $x = NQ$, the tangent from $N(T_1, O)$ to the circle C_1, and $x' = KR$, the tangent from $K(O_1T_1')$ to circle C'.

Through L', the intersection of (C_3) with the vertical LC through L, draw a line from N meeting (C_4) in the point ρ. Then $\sigma N:\rho N::CN:L'N$, where σ is the foot of the perpendicular from ρ upon the T-axis. Hence $\sigma N:T_1::\frac{v}{c}x:x$, giving $\sigma N = \frac{v}{c}T$. If (C_3) meets the T-axis in D_1, then $D\sigma = DN - \sigma N = x - \frac{v}{c}T_1$. Now lay off from O along the

position T-axis $O\tau = D\sigma$, and at τ erect a perpendicular to the T-axis, meeting OA at μ. Then $\tau\mu = \tan\theta \cdot O\tau = \alpha\left(x - \frac{v}{c}T_1\right)$. Hence we have, from (9), $\tau\mu = KR = x'$, where R is the point of contact of a tangent drawn from K to (C_1). Thus $\overline{OR}^2 = \overline{OK}^2 - \overline{KR}^2$, or $s^2 = (T_1')^2 - (x')^2 = \left\{\alpha\left(T_1 - \frac{v}{c}x\right)\right\}^2 - \left\{\alpha\left(x - \frac{v}{c}T_1\right)\right\}^2 = \alpha^2\left(1 - \frac{v^2}{c^2}\right)(T^2 - x^2)$ $= T^2 - x^2$, as in (5).

Next lay off any arbitrary line OE through O and construct, as indicated in the plate, the points U, I; V, W, where $OU = DC = \left(1 - \frac{v}{c}\right)x$, $OE = OX' + X'E = OX + CN = \left(1 + \frac{v}{c}\right)x$, $OV = OW = \left(1 - \frac{v}{c}\right)(T_1 + x)$ and $OB = OI = \left(1 + \frac{v}{c}\right)(T_1 - x)$. Now join W to $J\ (O, T_1' + x')$ and join I to $F(O, T_1' - x')$. Hence

$$T_1' - x' = (\tan \measuredangle OIF)\left(1 + \frac{v}{c}\right)(T_1 - x). \qquad (12)$$

and

$$T_1' + x' = (\tan \measuredangle OWJ)\left(1 - \frac{v}{c}\right)(T_1 + x) \ldots\ldots\ldots (13)$$

Now from equations (7) and (9), we immediately find

$$T' - x' = \alpha\left(1 + \frac{v}{c}\right)(T - x) \ldots\ldots\ldots\ldots\ldots (14)$$

and

$$T' + x' = \alpha\left(1 - \frac{v}{c}\right)(T + x) \ldots\ldots\ldots\ldots\ldots (15)$$

from which, on division, we find

$$\frac{T' - x'}{T' + x'} = \left(\frac{c + v}{c - v}\right)\left(\frac{T - x}{T + x}\right) \ldots\ldots\ldots\ldots\ldots (16)$$

Equations (14), (15), (16) exhibit the three relative invariants $T - x$, $T + x$, and $(T - x)/(T + x)$.

On comparing (12) with (14), and (13) with (15), we have

$$\tan \measuredangle OIF = \tan \measuredangle OWJ = \alpha = \tan\theta$$

Hence $\measuredangle OIF = \measuredangle OWJ = \measuredangle AON = \theta$.

Next lay off, along KL, KZ_1 (not shown in diagram) $= cKR = cx_1' \equiv cx'$,

$$\therefore \tan \measuredangle KOZ_1 = \frac{cx_1'}{T_1'} = \frac{c\alpha\left(x_1 - \frac{v}{c}T_1\right)}{\alpha\left(T_1 - \frac{v}{c}x_1\right)}, \quad \text{from (7) and (9).}$$

Making use of (4), we have

$$\tan \measuredangle KOZ_1 = \frac{x_1'}{t_1'} = \frac{x_1 - vt_1}{t_1 - \frac{v}{c^2}x_1} = \frac{\frac{x_1}{t_1} - v}{1 - \frac{v}{c^2}\cdot\frac{x_1}{t_1}}$$

$$\therefore \tan \measuredangle KOZ_1 = V_{x_1}' = \frac{V_{x_1} - v}{1 - \frac{vV_{x_1}}{c^2}} \tag{17}$$

which is the familiar formula for composition of velocities in Special Relativity.

It may be observed, from (4), that we have employed throughout the device of "slow-motion" time, so that 1 second in the "slow-motion" time is equal to 3 days 11 hours 20 minutes in the ordinary time. For any point on the portion of the branch of the hyperbola drawn in the figure, the ratio of the co-ordinates is equal to the ratio of the corresponding ordinary times. If we choose the upper half of the right-hand branch of the hyperbola, this is equivalent to reversing the sign of the relative velocity. Similar portions of the left-hand branch will correspond to changes of the signs of x and x', which would amount to certain readily distinguishable changes in the direction of motion. The quality of relative invariance in the diagram is shown in the property that, as P_1 traverses the hyperbola, the corresponding lines IF and WJ, in all positions make with the negative direction of the T-axis the same angle ($\theta = \tan^{-1} \alpha$, where α is the reciprocal of the Fitzgerald contraction factor) which OA makes with the positive direction of the T-axis. The property of absolute invariance, shown in equation (5), is indicated by the geometrical property, that x and x' are the lengths of the tangents from N and K respectively to the circle (C_1).

For low velocities, such as we ordinarily encounter in experience, the difference in the velocities, according to the formulas of Newtonian and Einsteinian mechanics, is slight, and often inappreciable. For example,

if the velocity of the moving belt is 20 feet per second, and the velocity of the car, moving in the same direction the belt is moving, with reference to the belt is 80 miles per hour; then the velocity of the car with reference to the floor of the building is, according to Newtonian mechanics

$$V = 80\,m/h + 20\,f/s = \frac{80 \times 5280}{3600}\,f/s + 20\,f/s$$

$$= 117\tfrac{1}{3}\,f/s + 20\,f/s = 137\tfrac{1}{3}\,f/s.$$

From formula (17), solving for V_{x_1}, we have

$$V_{x_1} = \frac{V'_{x_1} + v}{1 + \dfrac{V'_{x_1} v}{c^2}} = \frac{117\frac{1}{3} + 20}{1 + \dfrac{117\frac{1}{3} \times 20}{(186{,}000 \times 5280)^2}}\,f/s$$

$$= \frac{137\frac{1}{3}}{1 + \dfrac{7040}{(8{,}176{,}833{,}792)\,10^8}}$$

$$= \frac{412 \times 817{,}683{,}379{,}200{,}000{,}000}{2{,}453{,}050{,}137{,}600{,}021{,}120}$$

$$= \frac{336{,}885{,}552{,}230{,}400{,}000{,}000}{2{,}453{,}050{,}137{,}600{,}021{,}120}$$

$$= 137.33333333333332.$$

Hence the velocities differ by only about one hundred trillionth of a foot per second.

Suppose, however, we take high velocities.

Let $V'_{x_1} = 100{,}000\ m/s$ and $v = 100{,}000\ m/s$

Hence, according to the Newtonian mechanics,

$$V_{x_1} = X'_{x_1} + v = 200{,}000\ m/s$$

If, however, we use Einstein's formula, we have

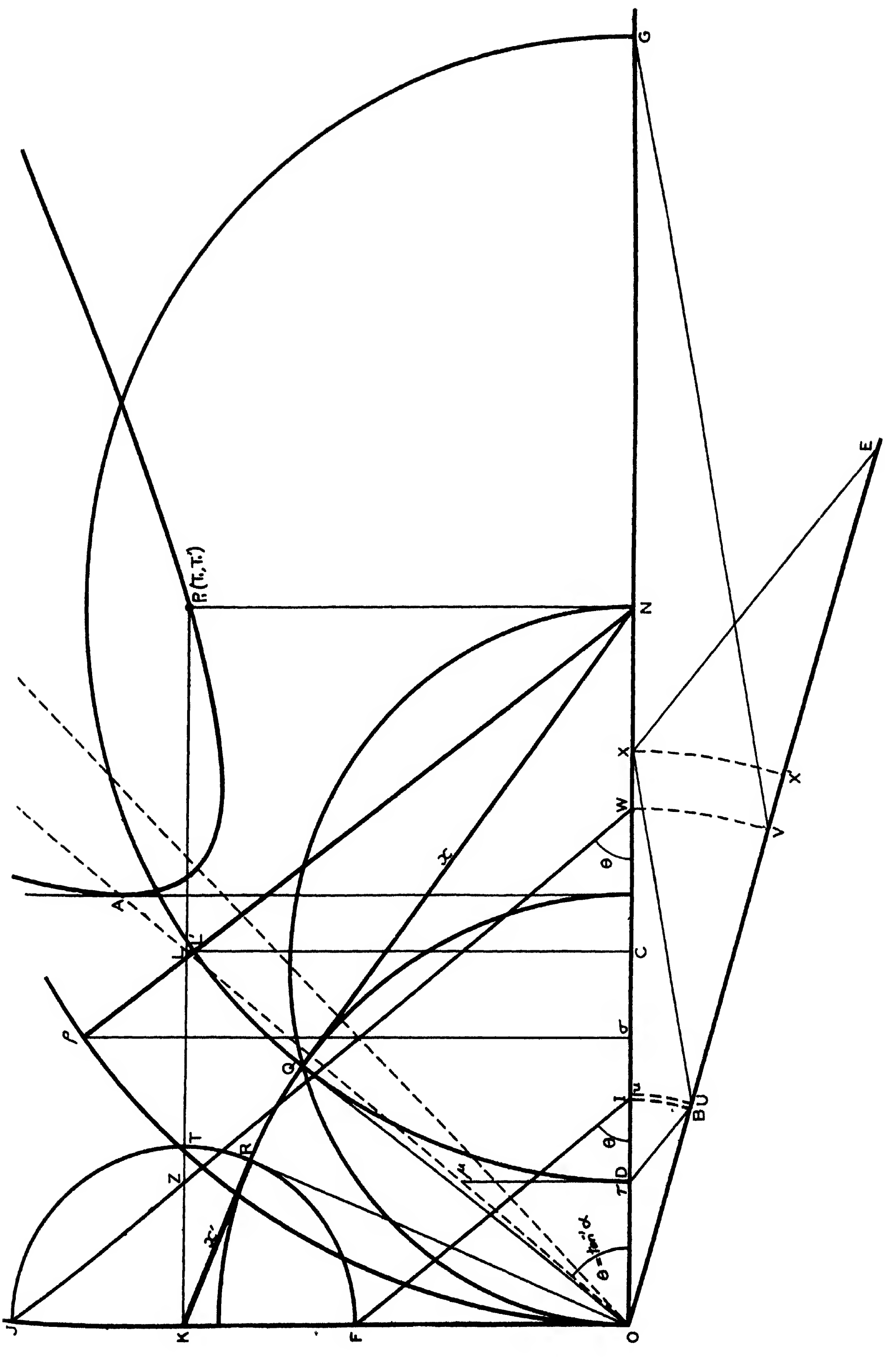
$$V_{x_1} = \frac{100{,}000 + 100{,}000}{1 + \dfrac{10{,}000{,}000{,}000}{34{,}596{,}000{,}000}} = \frac{6{,}919{,}200{,}000{,}000{,}000}{44{,}596{,}000{,}000}$$

$$= 155{,}153 \text{ miles per second, in round numbers.}$$

Hence the velocities differ by 44,847 miles per second.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

PLATE 7



HISTORY OF GEOLOGICAL INVESTIGATIONS IN NORTH CAROLINA

By Joseph Hyde Pratt

The earliest recorded investigation relating to the geology of North Carolina was that made in connection with the preparation of a geological map of the United States east of the Mississippi River, by William McClure, which was published in 1809.

McClure divided the rock formations into four classes:

Class I Primitive Rocks

Granite,	Primitive Limestone,
Gneiss,	Primitive trap,
Mica slate,	Primitive flinty rock,
Porphysy,	Primitive gypsum,
Quartz rock,	White stone,
Clay slate,	Serpentine,
Sienite,	Topaz rock.

Class II Transition Rocks

Transition limestone
Transition Trap
Gray wacke
Transition flinty slate
Transition gypsum

Class III Floetz or Secondary Rocks

Old Red sandstone or First sandstone formation
First or oldest Floetz-limestone
First or oldest Floetz-gypsum
Second or variegated sandstone
Second Floetz-gypsum
Second Floetz limestone
Third Floetz sandstone
Rock salt formation
Chalk formation
Floetz trap formation
Independent coal formation
Newest Floetz trap formation

Class IV Alluvial Rocks

Peat
Sand and gravel
Loam
Bog iron ore
Nagel-fluh
Calc-tuff
Calc-sinter

McClure's Class I, Primitive rocks, is approximately the area mapped on the U. S. Geological Survey maps as Archean for North Carolina; but it extends too far east and includes what are now known as the Triassic areas.

His Class II, Transition rocks, included a narrow belt of sedimentary rocks, along the Appalachian range, including various horizons from Algonkian to Carboniferous, Limestone and Marble.

His Class III, Floetz or secondary rocks, included the red sandstones and coal measures of North Carolina (Triassic).

His Class IV, Alluvial rocks, are those of our Coastal Plain region.

In 1816 Parker Cleveland published "Cleveland's Elementary Treatise on Mineralogy and Geology" which included a colored geological map based largely on McClure's work. The portion of the map covering North Carolina was approximately the same as shown on McClure's map of 1809.

In 1817 McClure published a second edition of his Geological Map of the United States. In this map he gave the distribution of the various geological formations in more detail, and also gave five sections across the United States from the Atlantic through the Appalachians. One section is across North Carolina from Cape Fear through "Warm Springs," now Hot Springs, North Carolina.

In 1819 Denison Olmsted, Professor of Chemistry at the University of North Carolina, announced the discovery of a red-sandstone formation in North Carolina and that he had traced it through the counties of Orange and Chatham, and that it was 7 miles wide in one place.

One interesting bit of North Carolina Geological History relates to the "Wall" observed on the banks of the Yadkin river near Salisbury, and first recorded in 1819 by Rev. James Hall and Zachariah Lewis, who considered the "Wall" to be the work of man. They described the blocks of the "Wall" as all being joined together by a "kind of cement." At the request of Dr. Samuel L. Mitchell, one time Professor of Natural Science in the College of Physicians and Surgeons, Mr. John Beckwith,

of Salisbury, North Carolina, made an examination of this occurrence and reported the result in a letter to Dr. Mitchell which was published in the American Journal of Science, Vol. 5, 1822. Beckwith considered them to be basaltic but rather of an aqueous than an igneous origin. Beckwith also mentioned in this letter that "this country abounds in beautiful slates," probably the first published reference to the Carolina Slates.

In 1823 Prof. Denison Olmsted was authorized by the President of the State Board of Agriculture to make a "Geological Survey" of the State; and the sum of $250 per year for a period of four years was appropriated. This was undoubtedly the first Geological Survey authorized by a state.

Olmsted's first report appeared in 1824, contained 44 pages, and was of an economic character dealing only with the distribution of minerals, such as graphite, gold, coal, and building stones. Although minerals had been produced for years in North Carolina, no geological study had been made of their occurrence.

In 1827 another report of Olmsted's was published which evidently had been prepared for publication in 1825. In this report considerable space was devoted to the agricultural possibilities of the State, and the suitability of the limestones and marls for use as fertilizers. He also devoted some space to a discussion of the great slate formation and its included rocks (Huronian of Kerr) and minerals. He referred to the "Huronian Wall" of Hall and Lewis, but ascribed it rightly to the natural jointing and decomposition of a basic igneous rock. He further noted that "the rocks are not, as in most other countries, particularly New England, exposed on the surface, but are very generally concealed by a thick covering of clay and sand." He deduced rightly that this was due to the decomposition of the rocks themselves and not due to "a deluge of water, as might at first be thought. (No glacial action in N. C. to scour the rocks.)

Prof. Olmsted left North Carolina in 1825 to accept the Professorship of Mathematics and Natural Philosophy at Yale College and was succeeded by Dr. Elisha Mitchell, who became Professor of Chemistry and continued the geological survey for two years.

In 1826 C. E. Rothe, of Saxony, who was Professor Mitchell's assistant, expressed the idea that the gold in what is now known as the Piedmont Plateau Region of North Carolina was "derived from the bursting asunder of the gold-bearing veins by subterranean explosives and the gold thus scattered over the adjacent region; some of it was spread over the country by a flood breaking through the Blue Ridge and

rushing in torrents over the entire gold-bearing region." Placer mining was the only form of mining for gold at that time.

In 1828, Professor Mitchell published a paper on the origin of the Low Country of North Carolina, and in 1829 a paper on the "Geology of the Gold Regions of North Carolina." In this paper he takes exception to the theories of Olmsted and Rothe and stated "that the gold occurred originally in veins and perhaps in part disseminated throughout the country rock, which was in itself in part primitive and in part secondary. From these rocks it was set free through atmospheric decomposition and subsequently distributed by gravity and running water." A colored geological map of the gold region accompanied this report and the rocks were classified as:

Primitive
Transition or Slate
Old red-sandstone
Alluvium

Although the Geological Survey was discontinued in 1828, Professor Mitchell at his own expense continued to make geological explorations to different sections of the state. These results were published in a text book, "Elements of Geology" with an outline of the geology of North Carolina.

Governor Dudley in 1838, Governor Morehead in 1844, Governor Graham in 1846 and 1848, and Governor Manly in 1850 or 1851 pointed out in their messages the advantages of continuing the Survey but nothing was done until the meeting of the General Assembly of 1850–51. The General Assembly of 1848–49 had authorized a Corporation, The Cape Fear and Deep River Navigation Company, to make the river above Fayetteville navigable up to and above the coal fields. There were supposed to be extensive coal and iron fields in Chatham County. People interested in these mineral fields and in the copper and other mineral deposits of Western North Carolina finally made themselves heard and the Second Survey Bill was passed (1850–51 General Assembly).

The work of the Tennessee Geological Survey which was formed in 1831 with Gerard Froost, Professor of Geology and Chemistry in the University of Nashville, as director, and continued to 1845, is a part of the geological history of North Carolina. Several of the investigations of the Survey were made in the Great Smoky Mountains, whose summits are the North Carolina-Tennessee line. His fifth report in 1839 was accompanied by a geological map of Tennessee with a colored cross-sec-

tion, extending from Roan Mountain west. Roan Mountain, which is partly in North Carolina, is considered as primitive (mostly granite). The Smoky Mountains which are also partly in North Carolina were mapped as transition (composed of gray wacke, slate, limestone, and sandstone).

In 1836, the Geological and Mineralogical Survey of New York was authorized. Among those who became connected with this Survey were Ebenezer Emmons (later State Geologist of North Carolina) and T. A. Conrad who later did geological work in North Carolina.

Conrad's work on the Tertiary formations begun in 1832 was published in 1845, in a volume on The Medial Tertiary Formations." He described this formation as extending into North Carolina.

The first geological map of North Carolina was prepared by Prof. Mitchell and published in 1842 in connection with the textbook for his classes.

In 1851 Ebenezer Emmons became State Geologist and director of the Second Geological Survey of North Carolina, and continued in that position until 1864.

There was no appropriation for the Survey and very little work done after the commencement of the War between the States.

In his first report he recognized the age of the coal fields of North Carolina as Triassic. He rejected the old classification of rock formations; (1) Primitive, (2) Transition, and (3) Tertiary and introduced the following:

1. Pyrocrystalline—Crystallized by the agency of fire.
2. Pyroplastic—Molded by fire.
3. Hydroplastic—Molded by water.

	Unstratified
Pyrocrystalline	granite
	hyperthium rock
	Stratified
	gneiss
	mica slate
	slate
	Modern
Pyroplastic	lavas, tuffs
	pumice
	Ancient
	basalt
	porphysy

	1. Tertiary System
Hydroplastic	Postpliocene
	Pliocene
	Miocene
	Eocene
	2. Cretaceous
	3. Triassic
	4. Permian
	5. Carboniferous
	6. Devonian
	7. Silurian
	8. Taconic

Other reports by Emmons were as follows:

In 1856, Geological Report of the Midland Counties of North Carolina. In this report he has a geological map of the Deep River coal field.

In 1858, A Report on the Agriculture of the Eastern Counties, together with Descriptions of the Fossils of the Marl Beds.

In 1860, A Report on Agriculture (Soils and Fertilizers), and a second Report on the Soils of the Swamp Lands.

In his 1858 report, Professor Emmons announced a principle which has since then been enunciated in somewhat different words by our most eminent authorities on soils, as follows:

"In the examination of soils the physical properties require as much attention as the chemical, for in order that a good chemical mixture of elements may be fertile, they should possess a certain degree of adhesiveness or closeness which will retain water."

In 1858, the Senate of the United States authorized and instructed the Secretary of the Navy "to cause a thorough examination of the iron, coal and timber of the Deep River County of North Carolina, and that he report upon the expediency of establishing, at some point in that State, machine and workshops for the construction of engines, boilers, etc., for naval vessels, and that he report the same to Congress at its next session." Resolution passed April 13, 1858.

This investigation was made during the months of August and September, 1858, and the report sent to the U. S. Senate January 17, 1859, and was ordered to be printed on February 9, 1858, and is known as the "Wilkes Report on the Deep River Country in North Carolina." In this report there is a rather detailed report of the geology of the Deep River coal field and of the iron ores of Chatham county, together with analyses of the coal and of the iron ores. There is also a section of the Deep River coal beds, as shown in the Egypt shaft, 160 ft. deep. This report added considerable information regarding the Triassic formations.

Edmund Ruffin of Virginia, in 1861, published a volume entitled, "Sketches (Agricultural, Geological and Descriptive) of Lower North Carolina and the Similar Adjacent Lands." Part I of this volume is entitled, "Agricultural Geology; or Remarks on the drift found and the denuded regions of the Atlantic slope." This report did not add much to the knowledge of geology of the region.

From 1861–64, the attention of the State Geologist and his assistants was turned to the manufacture of munitions of war for the use of the state military forces.

A great deal of material, representing manuscript reports on geological and mineralogical investigations, which it was estimated would make 1200 to 1300 octavo pages was lost or destroyed during the period of the War between the States. There was also lost a colored geological map of the State that was ready for publication.

In 1864, W. C. Kerr was appointed State Geologist, but there was no appropriation made with which to carry on the work of geological investigations. He was reappointed State Geologist by Governor Worth in 1866.

Kerr's first report was published in 1867, a 56 page report on Geology of Western North Carolina. The rocks of this area he regarded as belonging "to the most ancient of the Azoic series and to have been above sea level since very ancient times."

His second report in 1869 was also of 56 pages and related largely to Western North Carolina.

In 1873, Professor Kerr published a paper on "The Possible Influence of the Earth's rotation on the deflection of Rivers." He called attention to a fact which was very obvious and may have been evident to many people, i.e. that in both the Carolinas the eastward flowing rivers always presented high banks and bluffs on the south side and low plain and swamps on the north. In seeking a cause for this he rejected the slow subsidence theory of Michael Toumey, State Geologist of South Carolina, and suggested that it was due to the rotation of the earth co-acting with the force of the river currents. He quoted the laws of motions developed by Prof. W. Ferrel to sustain his opinion, i.e. "In whatever direction a body moves on the surface of the earth there is a force arising from the earth's rotation which deflects it to the right in the Northern but to the left in the Southern hemisphere."

Professor Collier Cobb, formerly of the University Geological Department, has also investigated and published a paper on this subject, entitled: "Notes on the deflective effect of the earth's rotation as

shown in streams" (Journal of the Elisha Mitchell Scientific Society 10: 26, 1893).

A report of Professor Kerr's, which was ready for publication in 1870 but was not published until 1875, was accompanied by a colored geological map and three colored sections. He adopted a classification of the rocks which is quite different not only from McClure and Cleveland but also from Mitchell and Emmons. Kerr's classification with Mitchell's and Emmon's for comparison is given below:

Mitchell 1842		*Emmons 1856*		*Kerr 1875*	
			Post Pliocene	Quarternary	
Tertiary		Tertiary	Pliocene		
			Miocene	Miocene	Tertiary
			Eocene	Eocene	
	Cretaceous			Cretaceous	
Secondary	Triassic			Triassic	
	Permian				
Transition		Taconic		Silurian	
				Huronian	
Primitive		Gneiss			
		Granite		Laurentian	
		Syenite			

This report gave a very fair summary of the geology of North Carolina up to 1875. Kerr considered at that time that the thin gravels overlying the eroded surfaces of the Eocene, Miocene, and Cretaceous in eastern North Carolina as of glacial origin, that the underlying rock had been planed down by the currents and drifting ice which brought boulders from the Achean hills to the west. North Carolina is now believed to be far south of the glacial limit.

In the work of the Geological Survey, Prof. Kerr was assisted by the Rev. C. D. Smith who studied particularly the occurrence of corundum and its associated basic magnesium rocks. He considered these rocks in which the corundum was found to be of igneous origin, although many geologists of that time believed them to be of sedimentary origin. Prof. Julian of Columbia University published a paper in which he described these rocks as of sedimentary origin. J. Volney Lewis and Joseph Hyde Pratt in 1905* described the occurrence of corundum in the basic magnesian rocks and considered the origin of the corundum and basic magnesian rocks as igneous.

Another who assisted Professor Kerr was F. A. Genth, of the Uni-

* N. C. Geological and Economic Survey, Vol. I, 1905.

versity of Pennsylvania, who investigated the occurrences of the minerals of the State. In 1871 he published a report "On the Mineral Resources of North Carolina." In 1885, a report by Professor Genth and Professor Kerr on "The Minerals and Mineral Localities of North Carolina" was published by the State Department of Agriculture.

Another report which appeared in 1885, added considerable information to the knowledge of the geology of the North Carolina coal fields. This was a report by Dr. H. M. Chance on the North Carolina Coal Fields. This report covered investigations of both the Deep River and the Dan River coal fields, and was the most elaborate and informative report on the Deep River coal field up to that time. A more thorough and detailed geological report was made during the Fifth Survey, by M. R. Campbell and Kent W. Kimball in 1922.

After the death of Professor Kerr in 1885, the large mass of material that he had been preparing for publication was turned over to Geo. B. Hanna of the U. S. Assay Office at Charlotte, North Carolina, to compile and make ready for publication.The report, "Ores of North Carolina," was completed in 1887 but was not published until 1893 after the creation of the Fourth Geological Survey.

The Fourth Survey was created by the General Assembly of 1891, and Joseph H. Holmes was appointed State Geologist. During that period of this Survey, 1891–1905, Professor Holmes was assisted by the following geologists: H. B. C. Nitze, J. Volney Lewis, Joseph Hyde Pratt, A. J. Wilkins, Heinrich Reis, and, in cooperation with the U. S. Geological Survey, by Arthur Keith, and George F. Becker.

Publications on the geology and mineralogy of the State were issued during this period as follows:

Bull. 1. Iron Ores of North Carolina by Nitze, 1893
Bull. 3. Gold Deposits of North Carolina by Nitze, 1896
Bull. 9. Monazite and Monazite Mining by Nitze, 1895
Bull. 11. Corundum and Basic Magnesium Rocks by Lewis, 1895
Bull. 13. Clay Deposits of North Carolina by Reis, 1897
Economic Paper No. 5. Talc and Pyrophyllite Deposits by Pratt, 1900
Economic Paper 4–8. Mining Industry in North Carolina for Years 1901–1904 by Pratt
Volume I. Corundum and the Peridotites by Pratt and Lewis, 1906

This Survey brought out a revision of the Kerr geological map which was published in the volume on Ores of North Carolina.

Very little pure geological work was done on the geology of the Pied-

mont Plateau Region. This is considered the state's most complicated geology. No fossils had thus far been found in that area. A new geological map of Western North Carolina was prepared and published in Volume I.

The Fifth Survey was authorized by Act of the General Assembly of North Carolina of 1905 (Chapter 542, Public Laws of North Carolina, 1905). The name of the new Survey was North Carolina Geological and Economic Survey and among its objects were:

1. An examination of the mineral, forest, fish, and other material resources of the State.

2. Examination of the geological formation of the State, with reference to their economic products.

This Survey continued until 1925, and during this period a decided advance was made in determining more accurately the geological formations and their extent; and of the occurrence and origin of mineral deposits. Geologists associated with the Survey as members of the State staff were:

Joseph Hyde Pratt, State Geologist
Collier Cobb, Geologist
Joseph E. Pogue, Geologist
Douglass B. Sterrett, Geologist
A. A. Steel, Geologist
W. S. Bayley, Geologist
Jasper L. Stuckey, Geologist
Fred Prouty, Geologist
George F. Kunz, Mineralogist

This Fifth Survey had, as did the Fourth Survey, the splendid cooperation of the U. S. Geological Survey and the members of the Federal Survey who cooperated in geological work in the State were:

William Bulloch Clark, Geologist
Benjamin L. Miller, Geologist
L. W. Stephenson and B. L. Miller, Paleontologists
B. L. Johnson, Geologist
T. Wayland Vaughan and Miss Mary J. Rathbaum, Paleontologists
M. R. Campbell, Geologist
Kent W. Kimball, Geologist
E. W. Berry and Miss Julia Gardner, Paleontologists
A. S. Watts, Geologist
G. F. Laughlin and J. A. Cushman, Geologists

Some of the outstanding geological investigations of this Survey were

those of the Cid Mining District by Pogue; the Gold Hill Mining District by Laney; the Coastal Plain Deposits of North Carolina and the Cretaceous Formation of North Carolina (Part I, Invertebrate Fossils).

The first two reports are detailed investigations of geological formations in the Piedmont area and are the first of this character to have been made; and these two reports have given a great deal of valuable and new information regarding the geology of that region.

The last two reports mentioned are reports of investigations relative to the geology of the Coastal Plain region of North Carolina, and from the information obtained a pretty accurate geological map of the region has been prepared.

Other geological and mineralogical reports of this Fifth Survey were:

History of Gems Found in North Carolina, by Kunz, 1907
Tin Deposits of North Carolina, Pratt and Sterrett, 1905
Zircon, Monazite, etc., Pratt, 1916
Limestones of North Carolina, Loughlin, Berry, Cushman, 1921
Recent Changes in Gold Mining, Pratt and Steel, 1907
Virgilina Copper District, Laney, 1917
Mica Deposits of North Carolina, Sterrett, 1911
Magnetic Iron Ores of Western North Carolina, Bayley, 1923
Brown Iron Ores, of Western North Carolina, Bayley, 1922
Kaolin of North Carolina, Bayley, 1922
Deep River Coal Field, Campbell, Kimball, 1923
Economic papers on the minerals of North Carolina, Pratt, 1905–1917.

CHAPEL HILL, N. C.

NOTES ON EPHEMEROPTERA AND AQUATIC DIPTERA OF WESTERN NORTH CAROLINA

By Thelma Howell

INTRODUCTION

The mayfly fauna of North Carolina was relatively unknown until the monumental work of Traver (1932a, 1932b, 1933, 1937), who recorded twenty-seven genera and about one hundred and fifty species. Two of the genera, Oreianthus and Stenonema, and approximately one-third of the species were new.

During the summers of 1938–40, the writer collected aquatic insects from one hundred stations in Western North Carolina.* Many of the records obtained for mayflies represent the first since Traver described the species; in other cases the records indicate greatly extended ranges. For these reasons certain mayfly collections are listed in this paper. Grateful acknowledgment is made of the help of Dr. Jay R. Traver who identified the specimens. Duplicate specimens are deposited at Duke University.

The most recent authoritative treatment of aquatic Diptera is that of Johannsen (1934 and 1935), who pointed out their economic importance and presented keys for the determination of the larvae and pupae of North American aquatic Diptera. In connection with some stream and lake surveys made for private individuals interested in fish culture and re-stocking projects, the writer collected aquatic Diptera representing nine families. Since many of the species collected are not reported by Brimley (1938), they are included in this paper. All specimens were identified by Dr. J. Speed Rogers, to whom grateful acknowledgment is made. Duplicate specimens are deposited at Duke University.

GEOGRAPHICAL AREA TREATED

The mountain plateau of North Carolina, lying between the Blue Ridge and the Great Smoky Mountains, has an area of approximately 6000 square miles. Numerous cross ranges connecting the two moun-

* The collections reported in this paper were made while holding a Duke University scholarship to the Sam T. Weyman Memorial Laboratory, Highlands, North Carolina, and while using the Duke University space there in 1939–40.

tain ranges create basins which preserve an altitude of 2000–2700 feet (Kerr, 1875). At the bottom of each basin there is a mountain tributary of the Tennessee River. These tributaries form parts of five great drainage basins: the New River Basin, the Watauga River Basin, the French Broad River Basin, the Little Tennessee River Basin, and the Hiwassee River Basin (Saville and Smith, 1925).

The records of aquatic insects from the mountain plateau as reported by Brimley (1938) indicate that a large part of the collecting was done in the streams making up the New, Watauga, and French Broad River basins. The stations referred to in this paper are located primarily on the Little Tennessee, Nantahala, and Tuckaseegee rivers and their tributaries, which, with the Cheowah River, make up the North Carolina part of the Little Tennessee River Drainage Basin. This drainage basin is located in the counties of Macon, Jackson, Swain, and Graham.

The Little Tennessee River, the largest west of the Blue Ridge, rises on the north slope of the Blue Ridge in Rabun County, Georgia, and flows northerly across Macon and a portion of Swain Counties. From the town of Franklin to the Tennessee line the river has a fall of over 900 feet (Kerr, 1875). From this point it takes a westerly course and crosses the Smoky Mountains in a narrow gorge of 4000 feet depth. The Nantahala and Cheowah rivers also join the Little Tennessee and contribute to give it a drainage area of 1881 square miles (Swain *et al.*, 1899).

The Tuckaseegee River rises on the northern slope of the Blue Ridge in the southern part of Jackson County, and throughout most of its course flows in a general northwesterly direction in a narrow, rocky channel. It has a drainage area of 833 square miles, 418 of which lie almost wholly in Jackson County (Swain *et al.*, 1899). The Oconalufty River, which rises in the Great Smoky Mountains, is the largest tributary of the Tuckaseegee.

The headwaters of the Nantahala River are in the extreme southwestern portion of Macon County, where the Nantahala and Valley River Mountains meet the Blue Ridge. It flows in a general northerly direction, traversing a deep basin from one to two thousand feet deep in places. Its drainage area is 184 square miles (Swain *et al.*, 1899).

STATIONS

The stations considered in this report are listed in a previous paper (Howell, 1939). With the exception of those stations mentioned below, they are located in the Little Tennessee River Basin.

The Savannah River Drainage Basin receives the waters from the streams draining the southern slopes of the Highlands Plateau (Saville and Smith, 1925). The following stations located in that basin are referred to in this paper: Clear Creek, Edwards Creek, Klines Lake, Overflow Creek, Chattooga River, Fowlers Creek, Greens Creek, Norton Mill Creek, High Hampton Lake, Toxaway River, and Lake Sapphire.

CLIMATIC FACTORS

From the establishment of the stations to 1930, inclusive, complete weather data are available from the United States Weather Bureau for only three stations in the Little Tennessee Drainage Basin: Cullowhee,

TABLE 1

*Average Monthly and Annual Temperature from the Establishment of the Station to 1940 Inclusive**

STATION	ALTITUDE	LENGTH OF RECORD	JAN.	FEB.	MCH.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
	feet	*yrs.*													
Cullowhee..	2100	21	39.5	41.5	47.6	55.5	62.7	70.2	73.1	72.4	68.4	57.7	46.0	39.8	56.2
Highlands.	3350	32	34.4	35.4	42.0	49.6	57.9	64.2	66.5	65.7	60.6	52.3	42.5	35.1	50.5
Rock House	3100	38	38.3	39.0	46.4	53.7	61.8	68.0	70.5	70.0	65.8	55.9	46.6	39.6	54.6

* From "Climatic Summary of the United States," Section 95—Western North Carolina. United States Department of Agriculture Weather Bureau.

Highlands, and the Rock House, near Highlands (Tables 1, 2). Since 1935 additional stations have been established by the Tennessee Valley Authority for recording rainfall data, but the length of the record is too short for definite conclusions. (Table 3). That local topography and differences in elevations affect the climate of the mountain plateau is well-known.

PHYSICAL FACTORS

During the course of this investigation water analyses were made on many of the streams. In all determinations the principles of the United States Bureau of Fisheries (Hazzard, 1935; Davis, 1938) were followed, and the chemical methods of the American Public Health Association

TABLE 2

*Average Monthly and Annual Precipitation in Inches and Hundredths from the Establishment of the Station to 1930 Inclusive**

STATION	ALTITUDE	LENGTH OF RECORD	JAN.	FEB.	MCH.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
	feet	*yrs*													
Cullowhee.	2100	21	3 98	3.69	4.75	3.14	3 68	3.98	4.27	3 63	3 44	2.75	2.39	4.26	43 96
Highlands	3350	24	6.91	7 49	7 81	6 45	5 40	7.14	8 46	7.08	6 43	5.61	5.47	7 45	81 73
Rock House	3100	40	6 71	6.78	7 46	6.04	6.00	7.66	8.85	8.06	6.73	5.46	5.03	7.69	82.47

* From "Climatic Summary of the United States," Section 95—Western North Carolina. United States Department of Agriculture Weather Bureau.

TABLE 3

*Annual Precipitation Little Tennessee River Basin**

STATION	COUNTY	ELEV.	ANNUAL PRECIPITATION				
			1935	1936	1937	1938	1939
		feet					
Jack Cove	Jackson	2,100	—	—	—	—	44 06
Dicks Creek	"	3,151	—	61 08	57 62	54.07	46.26
Erastus	"	3,500	—	78 53	61 95	50 76	58.32
Owens Gap	"	4,100	—	—	—	65.14	70.44
Haywood Gap	"	5,250	—	—	—	60.89	51 31
Franklin	Macon	2,002	38 24	64 06	46 93	45.96	40.19
Nantahala	"	2,100	47.32	65 56	56.04	62.82	49.49
Otto	"	2,300	—	73.19	53.98	52.01	50 60
Raven Mt.	"	4,500	—	66 47	67.42	54.93	45.99
Wayah Bald	"	5,330	—	74.90	74.30	70.47	58 91
Needmore	Swain	1,770	—	59.18	50.10	45.59	45 98
Proctor	"	2,400	—	68.13	61.08	58.69	49 85
Spruce Mt.	"	4,800	—	—	—	59.37	—
Clingmans Dome	"	6,400	—	—	88.28	86.65	61.58
Tapoca	Graham	1,112	51.23	61.86	58.93	64.78	—
Stecoah	"	2,350	—	69.85	67.61	57.67	47.30
Teyahalee Bald	"	4,750	—	—	—	68.40	58.61

* From "Climatological Data." N. C. Section U. S. Weather Bureau. Raleigh, N. C., 1935–40.

(1936) were employed. The results for several streams of particular interest are shown in Table 4.

The data for the Nantahala River and its tributaries—Wine Spring, White Oak, Cold Spring, and Choga creeks—may have greater significance at a future date because these streams will soon become a part of a large lake due to the construction of a dam by the Nantahala Power Company. The data may be of value as a basis of comparison with records of chemical and thermal characteristics of the impounded waters.

The Sam T. Weyman Memorial Laboratory, located on Lake Ravenel, Highlands, North Carolina, has been the headquarters for many investigators (Coker, 1939), but as far as is known no previous water analyses have been made on this lake. For that reason the records are reported here (Table 4).

TABLE 4

Physical Factors in Waters near Highlands, N. C.

STATION	DATE	ALTITUDE	TEMP.		pH	FREE CO_2	M. O. ALKALINITY	PHEN. ALK.	O_2
			Air	Water					
		feet	°C.	°C.		*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
Wine Spring Creek	9/ 5/40	3,080	29.0	15.0	6.8	0.50	12.00	0.00	9.32
Junc. White Oak and Cold Sp. Creeks	9/ 5/40	3,180	22.0	16.0	6.8	0.50	12.00	0.00	8.26
Choga Creek	9/ 5/40	2,900	26.0	17.0	7.0	—	—	—	9.60
Nantahala River	9/ 5/40	2,860	24.0	18.8	7.2	0.50	32.00	0.00	8.26
Lake Ravenel	5/30/40	3,820	20.0	21.0	6.8	1.00	20.00	0.00	7.85
Norton Mill Creek	6/ 1/40	2,860	24.5	17.0	6.8	1.00	20.00	0.00	8.77

Norton Mill Creek, which rises under the cliffs of Whiteside Mountain, has furnished many new records of aquatic insects for North Carolina (Howell, 1939). The results of water analyses made there and reported in this paper (Table 4) are the first records for that creek.

ORDER EPHEMEROPTERA—The Mayflies

Unless otherwise stated the specimens are nymphs.

Family EPHEMERIDAE

Sub-family EPHEMERINAE

Hexagenia carolina Traver

Macon County: July 1939, female subimago, Primeval Forest, Highlands, N. C.

Jackson County: July 20, 1939, West Fork Tuckaseegee River.

Hexagenia sp.

Jackson County: May 25, 1939, female subimago, High Hampton Lake. Note by Dr. Jay R. Traver "... it is too dark for most of the typical southern species....".

Sub-family NEOEPHEMERINAE

Oreianthus purpureus Traver

Macon County: July 26, 1939, Burningtown Creek.

Jackson County: March 20, 1939, Norton Mill Creek; June 18, 1939, Tuckaseegee River.

Family HEPTAGENIIDAE

Stenonema carolina Banks

Macon County: August 15, 1938, Primeval Forest, Highlands, N. C.; May 26, 1939, Cullasaja River; June 20, 1939, Big Creek; June 26, 1939, Burningtown Creek; July 28, 1939, Buck Creek.

Jackson County: June 13, 1939, East Fork Tuckaseegee River.

Swain County (Great Smoky Mountains National Park): August 16, 1939, Deep Creek.

Stenonema pudicum Hagen

Macon County: May 29, 1938, Cullasaja River; August 24, 1938, Big Creek; May 26, 1939, female subimago, Cullasaja River; May 20, 1939, Jarrett Creek and Nantahala River; June 20, 1939, Big Creek; June 27, 1939, White Oak Creek; July 26, 1939, Matlock Creek; July 28, 1939, Buck Creek.

Jackson County: August 8, 1938, Norton Mill Creek; August 11, 1938, Cullowhee Creek; March 20, 1939, Fowlers Creek and Norton Mill Creek; June 13, 1939, East Fork Tuckaseegee River.

Stenonema varium Traver?

Macon County: May 25, 1938, Cullasaja River; August 16, Wayah Creek; August 25, 1938, Overflow Creek; August 26, 1938, Edwards Creek; July 5, 1938, Chattooga River.

Stenonema vicarium Walker

Macon County: June 6, 1939, Highlands, N. C.

Stenonema sp. No. 1

Macon County: May 29, 1938, Cullasaja River.

Stenonema sp. No. 3

Macon County: August 15, 1938, Cullasaja River; June 20, 1939, Big Creek; July 4, 1939, near Highlands: July 26, 1939, Caler Fork Creek.

Jackson County: August 8, 10, 14, 28, 1938, Norton Mill Creek; August 17, 1938, Greens Creek; August 18, 1938, Fowlers Creek; July 20, 1939, Knob Creek.

Swain County (Great Smoky Mountains National Park): July 11, 1939, Indian Creek; August 13, 1939, female subimago, Forney Creek.

Transylvania County: June 5, 1939, Toxaway River.

Heptagenia aphrodite McDunnough

Jackson County: August 26, 1938, Chattooga River.

Heptagenia juno McDunnough
Jackson County: June 16, 1939, male subimago, East Fork Tuckaseegee River.

Heptagenia thetis Needham
Macon County: August 16, 1938, Wayah Creek; May 30, 1939, Junction Ball and Shope Creeks, Nantahala River; July 5, 1939, Tessentee Creek.
Jackson County: August 19, 1938, Fowlers Creek; June 12, East Fork Tuckaseegee River; July 20, 1939, West Fork Tuckaseegee River.
Swain County (Great Smoky Mountains National Park): August 13, 1939, Forney Creek; August 16, 1939, Deep Creek.

Rithrogena fasciata Traver?
Jackson County: July 20, 1939, Knob Creek and West Fork Tuckaseegee River.

Rithrogena fuscifrons Traver
Macon County: June 27, 1939, Wine Spring, White Oak, Otter, and Choga Creeks; June 24, 1939, Cullasaja River.
Swain County (Great Smoky Mountains National Park): July 11, 1939, Indian Creek; August 13, 1939, Forney Creek.

Rithrogena sp. No. 3
Macon County: June 27, 1939, Cold Spring Creek.

Iron subpallidus Traver
Macon County: June 3, 1938, June 20, 1939, Big Creek; July 28, 1939, Buck Creek.
Jackson County: June 13, 1939, East Fork Tuckaseegee River.
Swain County (Great Smoky Mountains National Park): July 11, 1939, Deep Creek.

Iron sp. No. 4
Macon County: June 27, 1939, Wine Spring and Choga Creeks.

Family BAETIDAE

Sub-family SIPHLONURINAE

Ameletus sp.
Jackson County: March 20, 1939, Fowlers Creek and Norton Mill Creek.

Isonychia aurea Traver?
Macon County: August 24, 1938, Big Creek; August 26, 1938, Edwards Creek.
Jackson County: August 1, 3, 10, 1938, Norton Mill Creek; August 19, 1938, Fowlers Creek; June 5, 1939, Rock Creek; July 6, 1939, Tennessee Creek; July 12, 1939, High Hampton Lake; July 20, 1939, Knob Creek and West Fork Tuckaseegee River.

Isonychia notata Traver
Jackson County: August 11, 1938, Cullowhee Creek.

Isonychia serrata Traver?
Macon County: July 28, 1939, Buck Creek.

Isonychia similis Traver?
Macon County: July 26, 1939, Matlock Creek.
Jackson County: August 10, 1938, Norton Mill Creek; August 11, 1938, Cullowhee Creek; July 6, 1939, Tennessee Creek.
Isonychia thalia Traver?
Macon County: July 26, 1939, Burningtown Creek.
Jackson County: July 6, 1939, Tennessee Creek.

Sub-family LEPTOPHLEBIINAE

Paraleptophlebia adoptiva McDunnough
Jackson County: March 20, 1939, Fowlers Creek and Norton Mill Creek.
Swain County (Great Smoky Mountains National Park): July 20, 1939, Bradley Fork.
Paraleptophlebia debilis Walker
Jackson County: July 12, 1939, feeder stream of High Hampton Lake, Cashiers.
Paraleptophlebia guttata McDunnough
Macon County: July 26, Burningtown Creek; September 5, 1940, male imagoes, Jarrett Creek.
Jackson County: August 17, 1938, Greens Creek.
Blasturus sp.
Macon County: May 31, 1940, Cullasaja River.
Jackson County: March 20, 1939, Norton Mill Creek.
Habrophlebia sp.
Macon County: May 26, 1939, Cullasaja River.
Jackson County: June 1, 1940, female imago, Norton Mill Creek.

Sub-family BAETISCINAE

Baetisca thomsenae Traver?
Transylvania County: June 5, 1939, Toxaway River.

Sub-family EPHEMERELLINAE

Ephemerella cherokee Traver
Macon County: July 26, 1939, Burningtown Creek.
Ephemerella conestee Traver
Macon County: August 25, 1938, Big Creek; August 25, 1938, Overflow Creek; August 26, 1938, Edwards Creek; June 27, 1939, Choga Creek; July 5, 1939, Buckeye Branch; July 26, 1939, Beasley Creek; July 28, 1939, Buck Creek.
Jackson County: August 11, 1938, Cullowhee Creek; August 18, 1938, Fowlers Creek; July 20, 1939, Knob Creek.
Swain County (Great Smoky Mountains National Park): August 13, 1939, Forney Creek.
Ephemerella doris Traver
Jackson County: June 8, 1939, Lake Sapphire, near Cashiers, N. C.

Ephemerella funeralis McDunnough?
Macon County: May 26, 1931, Cullasaja River; June 6, 1939, Highlands.
Jackson County: June 13, 1939, East Fork Tuckaseegee River.
Ephemerella inconstans Traver
Jackson County: March 20, 1939, Fowlers Creek, Norton Mill Creek.
Ephemerella longicornis Traver
Macon County: June 3, 1938, Big Creek; May 30, 1938, Dirty John Creek, Nantahala River; June 27, 1939, Wine Spring, Cold Spring, White Oak, Otter, and Choga Creeks; June 27, 1939, Nantahala River; July 28, 1939, Buck Creek.
Jackson County: June 12, 1939, East Fork Tuckaseegee River; June 18, 1939, Tuckaseegee River; July 6, 1939, Tennessee Creek; July 20, 1939, Knob Creek.
Swain County (Great Smoky Mountains National Park): July 11, 1939, Indian Creek.
Ephemerella rotunda Morgan
Jackson County: March 20, 1939, Fowlers Creek.
Ephemerella wayah Traver
Macon County: June 20, 1939, Cullasaja River; June 27, 1939, Cold Spring and Choga Creeks.
Jackson County: July 1, 1939, Chattooga River. Note by Dr. Jay R. Traver, "... with occipital spines ...".

Sub-family BAETINAE

Pseudocloeon carolina Banks
Swain County (Great Smoky Mountains National Park): July 2, 1939, Oconalufty River.
Acentrella sp.?
Macon County: August 24, 1938, Big Creek; August 25, 1938, Overflow Creek.
Jackson County: August 29, 1938, Chattooga River.
Cloeon sp.
Jackson County: June 1, 1940, male imago, Norton Mill Creek.

ORDER DIPTERA

Family TIPULIDAE

Sub-family LIMONIINAE

Limonia (D) pudicoides (Alex.)
Jackson County: June 12, 1939, adult, East Fork Tuckaseegee River.
Limonia (D) stulta (O.S.)
Jackson County: June 12, 1939, adult, East Fork Tuckaseegee River.
Antocha opalizans O.S.?
Macon County: June 1, 1938, larva, Big Creek; May 30, 1939, larva, Jarrett Creek.

Molophilus fultonensis
Jackson County: June 4, 1939, adult, Norton Mill Creek.
Limnophila sp.
Macon County: June 20, 1939, larva, Big Creek.
Hexatoma (E) aurata (Doane)
Jackson County: August 19, 1938, larva, Fowlers Creek.
Hexatoma (E) brachycera O.S.
Macon County: May 30, 1939, larva, Nantahala River; June 22, 1939, larva, Cullasaja River.
Jackson County: July 20, 1939, larva, Knob Creek.
Hexatoma (E) fuliginosa (O.S.)
Jackson County: June 12, 1939, adult, East Fork Tuckaseegee River; July 20, 1939, larva, West Fork Tuckaseegee River.
Hexatoma (E) fultonensis (Alex.)?
Macon County: July 26, 1939, larva, Burningtown Creek.
Hexatoma (E) spinosa (O.S.)
Macon County: August 26, 1938, larva, Edwards Creek.
Hexatoma megacera (O.S.)
Macon County: May 26, 1939, female, headwaters Cullasaja River.
Dicranota (A) flaveola (O.S.)
Jackson County: June 4, 1939, female, Norton Mill Creek; June 12, 1939, adult, East Fork Tuckaseegee River.
Dicranota (Rhaphidolabis) cayuga (Alex.)?
Macon County: May 30, 1939, larva, Junction Ball and Shope Creeks.
Jackson County: June 13, 1939, larva, East Fork Tuckaseegee River.
Pedicia (T) inconstans (O.S.)
Jackson County: June 4, 1939, female, Norton Mill Creek.
Pedicia albivitta (Walker)
Jackson County: March 21, 1939, larva, Norton Mill Creek.

Sub-family TIPULINAE

Dolichopeza americana Need.
Jackson County: June 12, 1939, adult, East Fork Tuckseegee River.
Longurio minimus Alex.?
Jackson County: July 6, 1939, larva, Tennessee Creek. The larva of *Longurio minimus* is unknown. This identification was by elimination. Specimen given to Dr. J. Speed Rogers.
Longurio testaceus Loew
Macon County: July 1938, female, Highlands.
Jackson County: July, August 1938, larvae, Whiteside Cove, near Norton Mill Creek.

Family CULICIDAE

Sub-family DIXINAE

Paradixa sp.
Macon County: June 6, 1939, larva, Highlands.

Family SIMULIIDAE

Simulium pictipes Hagen

Jackson County: June 5, 1939, larvae, Cashiers; June 28, 1939, larvae, Norton Mill Creek.

Transylvania County: June 5, 1939, larvae, Toxaway Falls.

Simulium venustum Say

Macon County: May 26, 1939, larva, Highlands; June 20, 1939, larva, Skittles Creek; June 27, 1939, larva, Choga Creek.

Jackson County: June 2, 1939, pupa, near Cashiers; June 5, 1939, larva, Luptons Lake, near Cashiers.

Haywood County: June 18, 1939, larvae, near Balsam.

Family BLEPHAROCERIDAE

Blepharocera tenuipes (Walker)

Macon County: June 20, 1939, larvae, Big Creek; June 27, 1939, larvae and pupae, Choga Creek.

Jackson County: June 2, 1939, larvae and pupae, Cashiers; June 18, 1939, pupa, near Balsam.

Swain County (Great Smoky Mountains National Park): July 2, 1939, larvae and pupae, Oconalufty River; July 11, 1939, larvae and pupae, Indian Creek.

SAM T. WEYMAN MEMORIAL LABORATORY,
HIGHLANDS, N. C.

DEPARTMENT OF BIOLOGY,
WESLEYAN COLLEGE,
MACON, GA.

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RECORDS OF THE BROOK LAMPREY, LAMPETRA AEPYPTERA (ABBOTT), FROM THE ATLANTIC DRAINAGE OF NORTH CAROLINA AND VIRGINIA

By Edward C. Raney

Among a number of interesting freshwater fishes collected by the writer[1] and students in North Carolina and Virginia during the past two years (early April, 1940 and 1941) is a specimen of the degenerate, non-parasitic brook lamprey, *Lampetra aepyptera* (Abbott). This record and additional hitherto unreported specimens in the collection of the United States National Museum extend the known range of this primitive fish many miles to the south. It now appears likely that *Lampetra aepyptera* has a widespread distribution in the small streams of the mid-Atlantic region and perhaps the publication of these records may stimulate further search for lampreys and other little known freshwater fishes especially in North Carolina, which is probably the area in eastern United States in greatest need of careful restudy.

According to Hubbs and Trautman (1937: 23), *Lampetra aepyptera* was recorded from the Atlantic drainage from but one locality, Laurel Run near Laurel, in eastern Maryland. It is somewhat more widespread in the upper Ohio River system and Creaser (1939: 169) has recently recorded it from a point as far west as the Wabash River system in southern Indiana. Recent records reported below now extend the known distribution to include the Neuse River system in North Carolina, the Rappahannock River system in Virginia and several additional localities in Maryland.

A single male specimen was taken by Ernest A. Lachner and the writer on April 6, 1940, in a small tributary of Little River (a tributary of the Neuse River) 1.5 miles northeast of Wendell on U. S. route 64, Wake County, North Carolina. A short description of the habitat is given here in hope that additional collecting in similar places in eastern North Carolina and Virginia may produce more specimens. The stream was 5 to 15 feet wide with a sand bottom and with long quiet pools and short riffles. The water was slightly brown and the flow was approximately 5 cubic feet per second. The *Lampetra* was taken

[1] The field studies were made possible by a grant from the Faculty Research Fund of Cornell University.

in a shallow riffle and thirty minutes of seining failed to reveal another specimen. Judging from the almost perfect external appearance of the lamprey it could hardly have spawned as yet although the water temperature was 67° F., a point at which spawning might be expected in this species.

The *Lampetra* is 135 mm. in total length and has 57 myomeres between the posterior gill-opening and the posterior end of the cloacal slit. The dentition is degenerate as is typical for this species although the anterior disk teeth are somewhat better developed than in specimens from Laurel Run, Maryland. The middle lateral is bicuspid on either side but the other laterals are small and with one cusp. No posterior disk teeth are present.

Two larvae now in the collections of the United States National Museum (No. 100276) were captured in Austin Run, a tributary of the Rappahannock River, south of Fredericksburg, U. S. route 1, Spotsylvania County, Virginia, on April 28, 1935, by G. S. Myers and E. W. Bailey. Although, in general, the specific identification of lamprey larvae is difficult if not impossible, these two specimens may be referred to *Lampetra aepyptera* with but little question. The myomere count is 57 and 59 respectively while *Petromyzon marinus*, the only other species which might be reasonably expected to occur there, would have approximately 70 myomeres. The American brook lamprey, *Entosphenus lamottenii* (Le Sueur), which is found in the Atlantic drainage of New York, New Jersey, and Maryland (Greene, 1935: 23) and which might range further south, has about 70 myomeres also. No *Ichthyomyzon* is known from Atlantic streams south of the St. Lawrence River System.

Many specimens of *Lampetra aepyptera* have been taken near Laurel, Maryland, in a tributary of the Patuxent River over a period of 50 years. In 1936 a single adult (U. S. N. M. 102362) was collected in Suitland Bog, Maryland, near the District of Columbia, by Paul Bartsch. In the spring of 1937 several specimens (U. S. N. M. 103760) were secured in a small brook in Anne Arundel County through Mr. William H. Bayliff.

The following key will facilitate the identification of adults of the three species of Petromyzonidae known to occur in North Carolina and Virginia. For a discussion of relationships see Hubbs and Creaser (1922).

1a. Disk teeth poorly developed and not in radiating series; no teeth other than the marginals on the posterior field of the disk..........................
Brook Lamprey. *Lampetra aepyptera* (Abbott)
Non-parasitic. In small streams of the Atlantic drainage.

1b. Disk teeth well developed, radiating in all directions from the esophageal opening and deflected backward toward the margin of the disk.

2a. Dorsal fin continuous, although somewhat emarginate; dorsal fin not separated by a sharp notch from the caudal fin...................... Ohio Lamprey, *Ichthyomyzon bdellium* (Jordan)

Parasitic. Large streams of the upper Tennessee River System (Hubbs and Trautman, 1937: 88)

2b. Dorsal fins two; dorsal fin separated from the caudal fin by a sharp notch .... Sea Lamprey. *Petromyzon marinus* Linnaeus

Parasitic. Inhabits the north Atlantic coast. Ascends some coastal streams to spawn in the spring (Smith, 1907: 28).

The writer wishes to thank Dr. Leonard P. Schultz, Curator of Fishes, United States National Museum, Washington, D. C., for the loan of specimens and for permission to publish the records from Virginia and Maryland.

DEPARTMENT OF ZOOLOGY,
CORNELL UNIVERSITY,
ITHACA, NEW YORK.

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CELLULOSE DECOMPOSITION BY THE SAPROPHYTIC CHYTRIDS[1]

By Alma J. Whiffen

Plate 8 and One Text Figure

In recent years much attention has been directed to the culture of the chytrids, the need of pure cultures being frequently emphasized. In 1939 there appeared two papers dealing with the culture of the chytrids. In the first paper Couch (1939) outlined the technic for the collection, isolation, and culture of the chytrids by which he had obtained a pure culture of *Cladochytrium replicatum*. In this same paper Couch reported the culture of *Rhizophlyctis rosea*, *Nowakowskiella elegans*, and *Siphonochytrium* nov. gen. (*Cylindrochytridium*) on filter paper. In the second paper Haskins (1939) described the growth of ten species of saprophytic chytrids on cellophane. None of Haskins' cultures nor Couch's cultures on filter paper was free from bacteria. Therefore, the true nature of the nutritional relationship existing between the chytrid and the cellulose was obscured by the presence of the contaminating bacteria. Whether the chytrid was utilizing the cellulose directly, or indirectly, possibly through the action of cellulose-decomposing bacteria, could be decided only by studies with pure cultures of the chytrids. It was first necessary to perfect a technic by which the saprophytic chytrids might be gotten into pure culture on synthetic media. Such a technic is described in this paper in connection with the demonstration of the cellulose-decomposing ability of certain of these saprophytic chytrids in pure culture.

CULTURE TECHNIC[2]

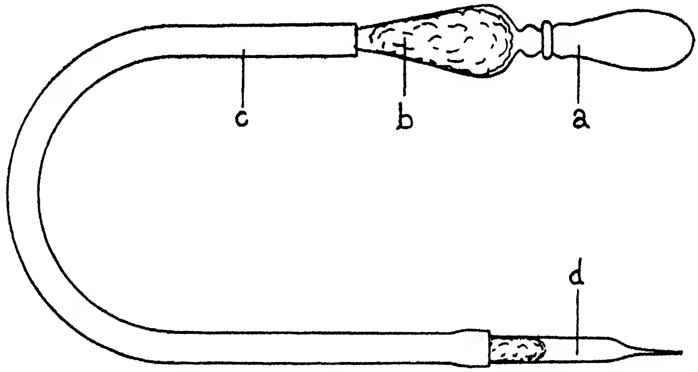
After a chytrid has been obtained in a unifungal culture on a suitable substratum, as boiled grass leaves (Couch, 1939), it is possible to estab-

[1] The study of cellulose decomposition by the chytrids was made while the author was serving as research assistant to Dr. J. N. Couch, which assistantship was made possible by a grant to Dr. Couch from the Carnegie Corporation of New York. This paper is a portion of the thesis submitted to the faculty of the University of North Carolina in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Botany.

[2] This pure culture technic was described in a paper entitled, "On Culturing

lish a pure culture of this chytrid by eliminating all bacteria. By use of the standard technic described below the following nine species of chytrids were gotten into pure culture: *Rhizophidium carpophilum* Zopf, *Rhizidiomyces apophysatus* Zopf, *Rhizophlyctis rosea* (deBary and Woron.) Fischer, *Entophlyctis* sp., *Endochytrium operculatum* (deWildeman) Karling, *Nephrochytrium aurantium* Whiffen, *Cylindrochytridium Johnstonii* Karling, *Nowakowskiella elegans* (Nowak.) Schroeter, and *Septochytrium variabile* Berdan.

An instrument was devised to facilitate the handling of the chytrid thalli, which are small and easily desiccated. This instrument is assembled as shown in the text figure. The capillary pipettes are sterilized in cotton-plugged test tubes, and when one is needed it may be quickly inserted in the end of the rubber tubing. The air pressure



TEXT FIGURE ONE. Dissecting Instrument. *a*. rubber bulb, *b*. cotton-filled bulb of a pipette from a dropping bottle, *c*. gum rubber tubing, *d*. capillary pipette.

within the capillary pipette is controlled by the degree of compression of the rubber bulb held in the left hand and the right hand is thus left free for manipulating the capillary pipette. By means of this instrument and a glass dissecting needle mature sporangia are dissected from the leaf tissue and segregated in a drop of sterile water in a Petri dish to await the next procedure.

It is desirable that the pure culture when established should be descended from a single sporangium, since one sporangium of a monocentric chytrid is developed from one spore. By the following procedure the spores are easily obtained from a single sporangium. The sporangia

Chytrids Free From Bacteria," which was read before the Mycological Society of America at Philadelphia, December, 1940.

are removed one at a time from the drop of sterile water and are transferred in a capillary pipette to a plate of three per cent plain agar, where all adhering bits of leaf tissue are torn away with glass dissecting needles. If this operation is performed carefully, relatively few bacteria will be carried with the sporangia when next they are transferred on a glass needle to a plate of one half per cent plain agar. After the spores have been discharged in this soft agar, they are able to swim about freely but at the same time are confined to the vicinity of the parent sporangium. In this way one need not wait for the discharge of a certain sporangium with the hope of catching the spores before they swim away.

The spore mass after its discharge on agar is mixed with bacteria that have adhered to the sporangium and so the chytrid spores must be separated from the bacteria. To accomplish this a dilution tube is prepared, consisting of a glass tube, which is drawn out to a fine point at one end, filled with about one cubic centimeter of water, and sterilized in a test tube. This dilution tube is attached to the rubber tubing, a portion of the water is expelled, and the spore mass is drawn up in the tube. The contents of the dilution tube are then dropped on several plates of one half per cent plain agar. The drops are allowed to run over the surface of the agar and in this way some of the chytrid spores will be able to germinate in areas of the agar free from bacteria. It is then possible to pick up these germlings on a sterile needle and transfer them to nutrient agar.

Three types of nutrient agar were used and to each was given a designating symbol as follows: ½ 13m agar (600 mg. maltose, 40 mg. meat peptone, 3 gm. agar, and 500 cc. mineral salt solution), D-N agar (2.5 gm. dextrose, 0.5 gm. ammonium nitrate, 500 cc. mineral salt solution, and 3 gm. agar), and C-N agar (0.5 gm. ammonium nitrate, 50 cc. cellulose suspension containing about 0.5 gm. of cellulose, 3 gm. agar, and 450 cc. mineral salt solution). The cellulose for the C-N agar was precipitated with sulphuric acid according to the directions of Scales (1915). The standard mineral salt solution was made up with the following constituents: 0.3 gm. K_2HPO_4, 0.2 gm. KH_2PO_4, 0.2 gm. $MgSO_4 7H_2 0$, 0.1 gm. Nacl, 0.1 gm. $Cacl_2 3H_2O$, 0.01 gm. $Fecl_2 4H_2O$, 0.001 gm. $ZnSO_4$-$7H_2O$, and 1000 cc. distilled water. The pH of the mineral salt solution was adjusted to 7.2 by the addition of N/20 NaOH.

Rhizophidium carpophilum and *Rhizidiomyces apophysatus* were cultured only on ½ 13m agar. This maltose-peptone agar was unfavorable to the growth of the other seven species in culture, which showed a preference for the D-N and C-N agars. The thalli grown in the

dextrose-ammonium nitrate agar were characterized by constricted rhizoids and an abnormal production of oil globules. The appearance of the thalli on the cellulose-ammonium nitrate agar, however, was more nearly like that of the chytrid when grown on grass leaves.

In Plate 8 are shown photographs of the thalli of nine species of chytrids now growing in culture on agar. A word of explanation must be given concerning the identity of two of these chytrids. The species of *Entophlyctis* (figs. 8 and 9) is the orange-colored chytrid reported by Couch (1939) and may be the same chytrid illustrated by Haskins (1939) as *Rhizophlyctis Petersenii* (?). It has the typical *Entophlyctis* type of development. The thallus of *Cylindrochytridium Johnstonii* (fig. 13), recently described by Karling (1941), is from the culture referred to by Couch (1939) as *Siphonochytrium* nov. gen.

CELLULOSE DECOMPOSITION[3]

Because previously no representative of the Phycomycetes has been found capable of decomposing cellulose, it is of particular interest now to discover that cellulose-decomposing ability is possessed by certain of the chytrids. In this paper is demonstrated cellulose decomposition by species of seven genera, *Rhizophlyctis*,[4] *Entophlyctis*, *Endochytrium*, *Cylindrochytridium*, *Nephrochytrium*, *Septochytrium*, and *Nowakowskiella*.

The method adopted to test for cellulose-decomposing ability consists of uniformly inoculating with a pure culture of the chytrid 500 cc. flasks, each containing 50 cc. of culture medium, consisting of distilled water, mineral salts, an inorganic nitrogen salt, and a weighed amount of cellulose. At the end of the incubation period the cellulose was again weighed and the loss of weight was determined, if such had occurred. The cellulose, in the form of grated filter paper or absorbent cotton, was oven dried at 110° C. for one hour and kept over calcium chloride in a desiccator until weighed. All experiments were performed at room temperature.

[3] Part of the material presented in this section was incorporated in a paper, "The Role of Chytrids in Cellulose Decomposition," read before the Botany Section of the North Carolina Academy of Science, April, 1941. This paper was the recipient of the Poteat Award of the North Carolina Academy of Science.

[4] In March, 1941, we received from Dr. Roger Yates Stanier of the Hopkins Marine Laboratory, California, a pure culture of a chytrid which we identified as *Rhizophlyctis rosea*. Stanier's strain of *R. rosea* has smaller spores and a paler color than the three strains described in this paper. In a letter to Dr. J. N. Couch, Dr. Stanier stated that he had found this organism to be capable of decomposing cellulose. The results of his work with this chytrid are now in press.

Rhizophlyctis rosea was the first chytrid to be found capable of decomposing cellulose. The decomposition of the cellulose by *R. rosea* was accompanied by the production of a reddish pigment which stained the undecomposed cellulose. The formation of a pigment was observed only in the case of this particular species.

Cellulose decomposition by three strains of *Rhizophlyctis rosea* was studied. Each of these strains exhibits certain distinct morphological characteristics but the variations among them is not considered sufficient to warrant describing the three strains as varieties of *R. rosea*. Strain one from Chapel Hill, North Carolina, has large sporangia (up to 275 μ) with long exit tubes and shows a tendency to a bilateral symmetry (fig. 5). This strain has not produced any resting bodies while in culture. Strain two (fig. 6) was isolated from soil from Greenville, South Carolina, and is characterized by constantly spherical sporangia with short exit tubes. This strain produces resting bodies in single spore cultures. The third strain (fig. 7), isolated by Miss Ward (1939) from a water collection from Burgaw, North Carolina, has exit tubes which are short and more numerous than those of strain two. No resting bodies have appeared in cultures of strain three since its collection. Ward (1939) grew this strain on agar containing precipitated cellulose but the culture was not free from bacteria.

TABLE I

Cellulose Decomposition by Rhizophlyctis rosea, Strains 1, 2, 3, 4

Cellulose supplied as grated filter paper; 1 mg. NH_4NO_3 per cc. medium; average taken of duplicate flasks.

STRAIN	MEDIUM	INCUBATION PERIOD	CELLULOSE SUPPLIED	CELLULOSE DECOMPOSED	pH
		days	*mg.*	*mg.*	
1	Buffered	10	100.2	none	7.0
	Unbuffered	10	100.3	22.4	4.9
2	Buffered	10	100.2	28.6	6.6
	Unbuffered	10	100.6	26.1	4.8
3	Buffered	9	100.3	16.6	6.6
	Unbuffered	9	100.8	32.8	4 4

The first experiment with *R. rosea* was designed to show the effect of a buffered and an unbuffered medium upon cellulose decomposition by the three strains of *Rhizophlyctis rosea*. The results are shown in Table I. In the buffered series potassium dihydrogen phosphate and sodium

hydroxide were added to the mineral salt solution so that the final pH was 7.2. The formula for one liter of buffered salt solution is as follows: 125 cc. .2 M KH_2PO_4, 37 cc. .2 M NaOH, 788 cc. distilled water, 0.2 gm. $MgSO_4 7H_2O$, 0.1 gm. $CaCl_2 3H_2O$, 0.01 gm. $FeCl_2 4H_2O$, and 0.001 gm. $ZnSO_4 7H_2O$. In the unbuffered series the mineral salt solution was made up as described above in the preparation of the agar culture media. The nitrogen in both series was supplied by one milligram of ammonium nitrate for each cubic centimeter of culture medium.

In each series the culture medium showed a marked increase in acidity by the end of the incubation period. The amount of cellulose decomposed was affected by the presence or absence of a buffer. Strain one did not grow at all in the buffered medium. Strain two decomposed

TABLE II

Effect of Nitrogen Supply on Cellulose Decomposition by Rhizophlyctis rosea, Strain 3

Cellulose supplied as absorbent cotton; average taken of four flasks

MEDIUM	INCUBATION PERIOD	CELLULOSE SUPPLIED	CELLULOSE DECOMPOSED	pH
	days	*mg.*	*mg.*	
Peptone, 5 mg. per 50 cc.	14	55.2	3.60	7.2
Glycine, 50 mg. per 50 cc.	14	54.5	10.8	7.0
KNO_3, 50 mg. per 50 cc.	14	53.9	17.3	7.2
$(NH_4)_2SO_4$, 50 mg. per 50 cc.	14	54.0	17.1	5.2

approximately equal amounts of cellulose in the buffered and unbuffered media. Strain three decomposed more cellulose in the unbuffered medium than in the buffered medium.

The loss of weight in the cellulose in each flask was sufficient to indicate very definitely the cellulose-decomposing ability of *Rhizophlyctis rosea*. In addition the results of this experiment indicate that not all of the strains of *R. rosea* under the conditions of the experiment are equal in their ability to decompose cellulose. Strain three was the most active of the three strains tested.

The results of a second experiment with *R. rosea* appear in Table II. The purpose of this experiment was to study the effect of the source of nitrogen upon the amount of cellulose decomposed by strain three in a buffered medium. Two organic and two inorganic sources of nitrogen were used. Only an average of 3.6 milligrams of cellulose was decom-

posed in the medium containing Witte's meat peptone. The amount of cellulose decomposed in the glycine medium was greater than in the peptone medium but much less than in the media with the inorganic nitrogen salts. As much cellulose was decomposed when potassium nitrate was utilized as when ammonium sulphate was the source of nitrogen. Although able to utilize both organic and inorganic nitrogen in the form of a peptone, an amino acid, a nitrate salt and an ammonium salt, *Rhizophlyctis rosea* was able to decompose a greater amount of cellulose when supplied with inorganic nitrogen. The pH remained the same in the media containing peptone and potassium nitrate but the acidity in the ammonium sulphate medium increased to pH 5.2.

TABLE III

Cellulose Decomposition by Entophlyctis sp., Endochytrium operculatum, Cylindrochytridium Johnstonii, Nowakowskiella elegans, Nephrochytrium aurantium, and Septochytrium variabile

Cellulose supplied as grated filter paper; 1 mg. NH_4NO_3 per cc. of medium; buffer — 1 mg. $CaCO_3$ per cc. of medium; average taken of duplicate flasks.

ORGANISM	INCUBATION PERIOD	CELLULOSE SUPPLIED	CELLULOSE DECOMPOSED	pH
	days	*mg.*	*mg.*	
Entophlyctis sp.	14	101.1	36.6	6.6
Endochytrium operculatum	14	102.9	26.0	6.7
Cylindrochytridium Johnstonii	14	104.3	37.6	6.6
Nowakowskiella elegans	14	101.9	65.8	6.5
Nephrochytrium aurantium	14	99.2	17.7	6.5
Septochytrium variabile	14	98.8	36.2	6.4

Six other species, *Entophlyctis* sp., *Endochytrium operculatum*, *Cylindrochytridium Johnstonii*, *Nowakowskiella elegans*, *Nephrochytrium aurantium*, and *Septochytrium variabile* were tested and were found capable of decomposing cellulose. The medium was buffered by calcium carbonate. The results of this experiment are summarized in Table III.

Nowakowskiella elegans showed a marked superiority in cellulose-decomposing ability over the five other species in this experiment. The polycentric nature of this chytrid and consequently its extensive vegetative growth may account in part for its ability to decompose a greater amount of cellulose than the monocentric chytrids. *Septochytrium variabile*, of course, is a polycentric chytrid but this species does not produce the extensive rhizomycelium that does *Nowakowskiella elegans*.

Rhizophidium carpophilum and *Rhizidiomyces apophysatus* were also

tested but neither species was able to decompose cellulose in any of the media used. When *Rhizophidium* and *Rhizidiomyces* failed to decompose cellulose in an unbuffered medium containing ammonium nitrate as the source of nitrogen, it was thought that perhaps these two species were unable to utilize inorganic nitrogen salts. Furthermore, it had been found that these two species made very poor growth in a culture medium containing mineral salts, dextrose, and ammonium nitrate. Therefore, a medium was prepared with meat peptone and cellulose. The cellulose showed no loss in weight at the end of the incubation period, though microscopic examination of the medium revealed that a limited amount of growth had occurred in the culture medium. This growth must have been possible due to the chytrid's utilization of the peptone as both a source of energy and carbon and of nitrogen. It is possible, of course, that these two species are able to decompose cellulose under conditions not yet known, though there is much evidence to deny this possibility.

DISCUSSION

The results recorded here of cellulose decomposition by seven species of chytrids are of a preliminary nature. Because the conditions of each experiment varied as to temperature, buffer content of the medium, and length of incubation period, no accurate comparison can be made as to the relative cellulose-decomposing ability of each species. It is conclusively demonstrated, however, that each of these seven species of chytrids in pure culture does possess a definite ability to decompose cellulose in a medium containing cellulose as the only source of carbon and energy. In such a culture medium the fact that the chytrid thalli grow and multiply in number and that the cellulose quantitatively loses weight is definite proof that the cellulose is being decomposed by the pure culture of the chytrid.

The nine species of chytrids discussed here are all commonly found in the soil, *Rhizophlyctis rosea* being the species most frequently appearing in soil collections. The facts regarding the nutrition of these chytrids obtained from studies with pure cultures may not apply directly to the determination of the activities of these same chytrids in the soil. Yet these experiments with pure cultures do indicate an interesting generalization that may be made in regard to the nutrition of the saprophytic chytrids. The saprophytic chytrids may be divided into two groups as to their type of nutrition. One group, represented by *Rhizophlyctis rosea*, *Entophlyctis* sp., *Endochytrium operculatum*, *Cylindro-*

chytridium Johnstonii, *Nephrochytrium aurantium*, *Nowakowskiella elegans* and *Septochytrium variabile*, decomposes cellulose and shows a preference for inorganic nitrogen salts as the source of nitrogen. The other group, represented by *Rhizophidium carpophilum* and *Rhizidiomyces apophysatus*, does not decompose cellulose and does not readily utilize inorganic nitrogen.

ACKNOWLEDGMENTS

I am indebted to Dr. J. N. Couch, whose example and encouragement made possible the execution of this study in the culture of the chytrids, and to Dr. J. E. Adams, whose assistance in the technical problems involved in this study was given freely at all times. I wish to thank Mr. Hiden Cox for the preparation of the text figure.

SUMMARY

A technic is described by which pure cultures were obtained of nine species of saprophytic chytrids.

By means of a culture medium containing mineral salts, ammonium nitrate, and cellulose, and inoculated with a pure culture of a chytrid, cellulose-decomposing ability was demonstrated in seven species of chytrids, *Rhizophlyctis rosea*, *Entophlyctis* sp., *Endochytrium operculatum*, *Cylindrochytridium Johnstonii*, *Nephrochytrium aurantium*, *Nowakowskiella elegans*, and *Septochytrium variabile*. Two species, *Rhizophidium carpophilum* and *Rhizidiomyces apophysatus*, did not decompose cellulose.

The species which decompose cellulose prefer inorganic nitrogen salts while the species which do not decompose cellulose prefer organic nitrogen compounds as the source of nitrogen.

BOTANY DEPARTMENT,
UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

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PLATE 8

Photomicrographs

Fig. 1. Thallus of *Rhizophidium carpophilum* on ½ 13m agar. × 150.

Fig. 2. Portion of agar culture of *R. carpophilum* showing concentric growth rings. × 25.

Fig. 3. Resting body of *R. carpophilum* formed in a glucose-tyrosine solution × 1200.

Fig. 4. Culture of *Rhizidiomyces apophysatus* on ½ 13m agar. × 100.

Fig. 5. Strain one of *Rhizophlyctis rosea* on ½ 13m agar. × 100.

Fig. 6. Strain two of *R. rosea* on C-N agar. × 150.

Fig. 7. Strain three of *R. rosea* on C-N agar. × 150.

Fig. 8. Mature sporangium of *Entophlyctis* sp. on D-N agar. × 150.

Fig. 9. Young thallus of *Entophlyctis* sp., illustrating the *Entophlyctis* type of development. × 635.

Fig. 10. Monocentric thallus of *Septochytrium variabile* on C-N agar. × 150.

Fig. 11. Margin of culture of *Endochytrium operculatum* on D-N agar. × 150

Fig. 12. *Nephrochytrium aurantium* on D-N agar. × 150.

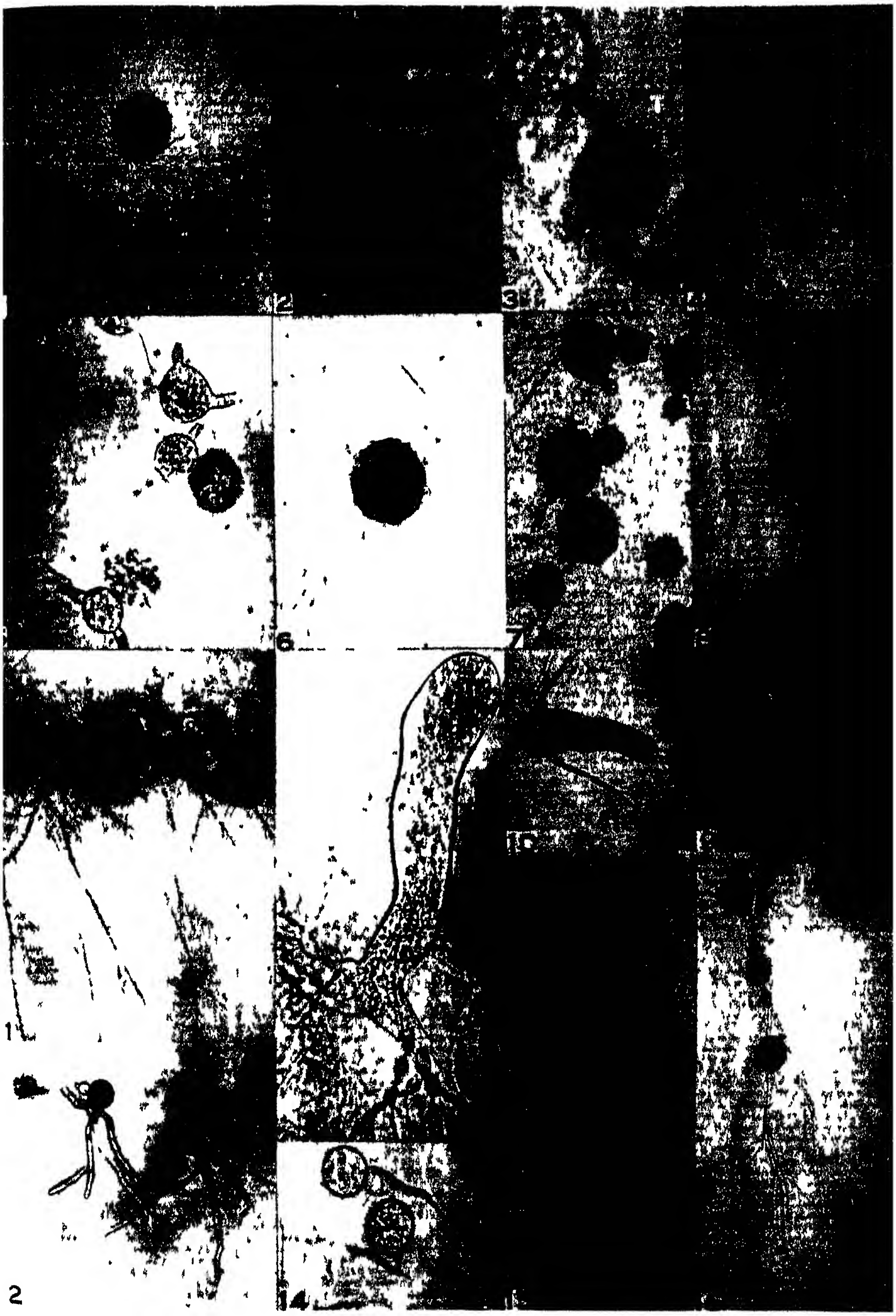
Fig. 13. *Cylindrochytridium Johnstonii* on D-N agar. × 335.

Fig. 14. Sporangia of *Nowakowskiella elegans* on C-N agar. × 335.

Fig. 15. Rhizomycelium of *N. elegans* on D-N agar. × 150.

Fig. 16. Polycentric thallus of *Septochytrium variabile* on C-N agar. × 150.

PLATE 8



PROCEEDINGS OF THE FIRST MEETING OF THE SOUTHEASTERN SECTION OF THE BOTANICAL SOCIETY OF AMERICA*

The first meeting of the Southeastern Section was held June 14–17, 1940, at Highlands, North Carolina. Twenty-four members and visitors attended the meeting. Among the visitors were Dr. Irwin Boeshare of the University of Pennsylvania and Dr. Mildred E. Faust of Syracuse University.

The first day was set aside for field trips to points of interest within walking distance of the village of Highlands. After an inspection of the Highlands Biological Laboratory the most important event was a visit to the famous Dry Falls of the Cullasaja River. Here the visiting botanists had the opportunity of seeing the southernmost stations of the narrow beach fern (*Phegopteris polypodioides*) and *Sphagnum squarrosum*. Some miles below on a tributary to the same river, near the high Cullasaja Falls, is the only known North Carolina station for *Trichomanes Boschianum*.

On Sunday a trip was made in search of the famous *Shortia galacifolia*, the type locality of which is located in the Highlands region. After a somewhat adventurous trip due to occasional showers and slippery roads, a large colony of the plant was at last located. The experience of having seen this rare endemic in its native haunts proved to be a satisfactory recompense for a rather strenuous day.

On Sunday evening after a delightful dinner at the Tricemont Hotel, a short business meeting was held at which the present officers were reelected for another year. The conclusion of the day's program was an interesting address by Dr. W. C. Coker of the University of North Carolina on "Some Early Southern Botanists." Dr. Coker discussed especially some of the personal characteristics of such men as Moses A. Curtis, Dr. Short, and Mr. Buckley.

On Monday, the final day of the meeting, trips were made to the

* It was the intention to publish these proceedings in *Science*, but by some oversight this was neglected. In order that the records of the section should be available, we publish them here. The proceedings of the second meeting, Charleston, S. C., June 1941, were published in Science 94: 69, 1941.—Ed.

Primeval Forest, one of the few virgin forests in the eastern United States, and to the nearby Whiteside Mountain.

The following report concerning the organization of the section was presented by the secretary.

At the meeting of the Botanical Society of America at Richmond, Virginia, December 28–30, the following proposal was presented to the Council of the Society:

"That the Botanical Society of America consider the creation of a Southeastern Section in accordance with the aims and specifications as follows:

"1. That the aims of the Southeastern Section shall be:
   a. To establish closer contacts between the botanists of this region who, for the most part, are scattered
   b. To undertake to increase the professional interest in botany in the Southeastern States and to increase the membership in the Society, thus stimulating interest and at the same time providing the advantages of a national publication.

"2. That its geographical boundaries be tentatively set so as to include the states of Virginia south to Florida, west to Louisiana and north to Kentucky and West Virginia east of the Mississippi River.

"3. That the Southeastern Section have the usual sectional organization of chairman and secretary.

"4. That the Southeastern Section be granted fifty cents per member from the Society for incidental expenses, such as postage necessary for organization of meetings, etc."

This proposal, so far as it provided for the creation of a Southeastern Section, was passed by the Council, and the writer was authorized to proceed with the organization and the election of officers.

In accordance with this authorization an announcement of the creation of a Southeastern Section was sent out to all members of the Botanical Society residing within the region tentatively specified in the original proposal. Included with this announcement was a blank ballot for the election of chairman and secretary. The result of this ballot was as follows: Chairman, W. C. Coker, The University of North Carolina; secretary, H. L. Blomquist, Duke University.

Among some of the letters received in response to the announcement of the creation of the Southeastern Section, there was a mixture of expression of approval and disapproval of having this regional section.

The disapprovals seemed to have been based upon a misunderstanding of what constitutes the new section and its aims. Such remarks as "Why have another section when we have too many organizations already?" and "I cannot afford to pay any more dues to societies" were typical.

Obviously the Southeastern Section is not just another organization. It is part of the Botanical Society of America and its aims are those stated above in the original proposal for its creation.

As to extra membership dues, there are none. Any member of the Botanical Society of America who happens to be located in the Southeastern States becomes automatically an active member of this section, if he so desires, without the payment of any more dues. Furthermore, by an act of the Council of the Society at the meeting in Columbus, Ohio, a small amount per member will be paid by the Society to the regional sections for minor expenses, such as postage and mimeographing in connection with organizing regional meetings, etc.

It has been customary in regional sections to hold summer meetings. Nothing is more conducive to carrying out the aims of the Southeastern Section than such meetings. As these meetings are informal and the reading of papers is reduced to a minimum, the botanists have an opportunity to really get acquainted. Furthermore, by distributing the meetings throughout the region from year to year, the botanists who attend these meetings become better acquainted with the botanical opportunities in this section of the country.

H. L. BLOMQUIST, *Secretary*.